# APPENDIX D

## Economics
## For The Lake Okeechobee Regulation Schedule Study

U.S. Army Corps of Engineers
Jacksonville District

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# 1. INTRODUCTION

## BACKGROUND

Lake Okeechobee is a large, freshwater lake located in central Florida. The lake is regulated for flood control and water supply purposes and is the heart of south Florida's water management system. During the wet season, lake levels are regulated to reduce potential flood damages by storing enormous volumes of water. During the dry season, stored water is released to support the Everglades ecosystem and to provide water supply to south Florida's municipal and industrial users and irrigated agriculture.

Lake levels are actively managed during high and low water conditions. The principal purpose of the Lake Okeechobee regulation schedule (LORS) is to control high water conditions. The potential for heavy rains and severe tropical storms in south Florida requires that the lake be carefully monitored to ensure that water levels do not threaten the structural integrity of the levee system surrounding the lake. When water levels in Lake Okeechobee reach certain elevations designated by the operating schedule, regulatory releases are made through the major outlets to control excessive buildup of water in the lake. The principal outlets are the Caloosahatchee River, which flows westward to Ft. Myers and the Gulf of Mexico; and the St. Lucie Canal, which extends eastward to Stuart and the Atlantic Ocean. Conversely, when lake water levels are excessively low, such as during droughts, the lake undergoes supply-side management (SSM), and releases are restricted to conserve stored water. The outcome of these management measures has been fluctuations in lake levels that are roughly twice the range of historical conditions.

In recent years, three categories of environmental concerns have arisen regarding the operation of Lake Okeechobee. First, extended periods of high lake levels stress the lake's littoral zone, which provides important fish and wildlife habitat. Second, insufficient water releases from Lake Okeechobee to the Everglades have contributed to the deterioration of the Everglades ecosystems. Third, high-water (regulatory) releases from the lake have contributed to ecological deterioration in the Caloosahatchee and St. Lucie estuaries through salinity effects on these sensitive ecosystems.

The U.S. Army Corps of Engineers (Corps) is conducting the Lake Okeechobee Regulation Schedule Study (LORSS) to evaluate the feasibility of modifying the lake's regulation schedule. The purpose of the LORSS is to attempt to formulate alternative lake regulation schedules that will reverse ecological damages while continuing to meet flood damage reduction and water supply needs. The LORSS is being conducted in cooperation with the South Florida Water Management District (SFWMD), the non-Federal sponsor.

In addition to the environmental, flood damage reduction, and urban and agricultural water supply parameters, there are other considerations that enter into decision making regarding management of Lake Okeechobee. These considerations include: (1) commercial navigation across the Florida peninsula via the Lake Okeechobee Waterway, which includes Lake Okeechobee, the Caloosahatchee River, and the St. Lucie Canal, (2) the lake's extensive recreational resources, which include a very popular sport fishery, and (3) commercial fishing on the lake. In addition, there is public concern that releases of fresh water to the Atlantic Ocean and the Gulf of Mexico are a waste of scarce water resources in a state with increasing water shortages.

## 1.1 PURPOSE OF THIS INVESTIGATION

This investigation explores the economic consequences of the four LORSS alternative regulation schedules (i.e., lake management plans) and the current regulation schedule. This economic evaluation will focus on agricultural and urban water supply, recreation, navigation, and commercial fishing. Specifically, the differences between the with- and without-project future conditions will be estimated to anticipate the effects of the alternative regulation schedules. Economic effects will be presented in terms of both net national effects (National Economic Development [NED]) and regional effects (Regional Economic Development [RED]). The procedures for estimating NED and RED effects are described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (22 April 2000) Engineering Regulation (ER) 1105-2-100(22 April 2000), and other Corps planning guidance.

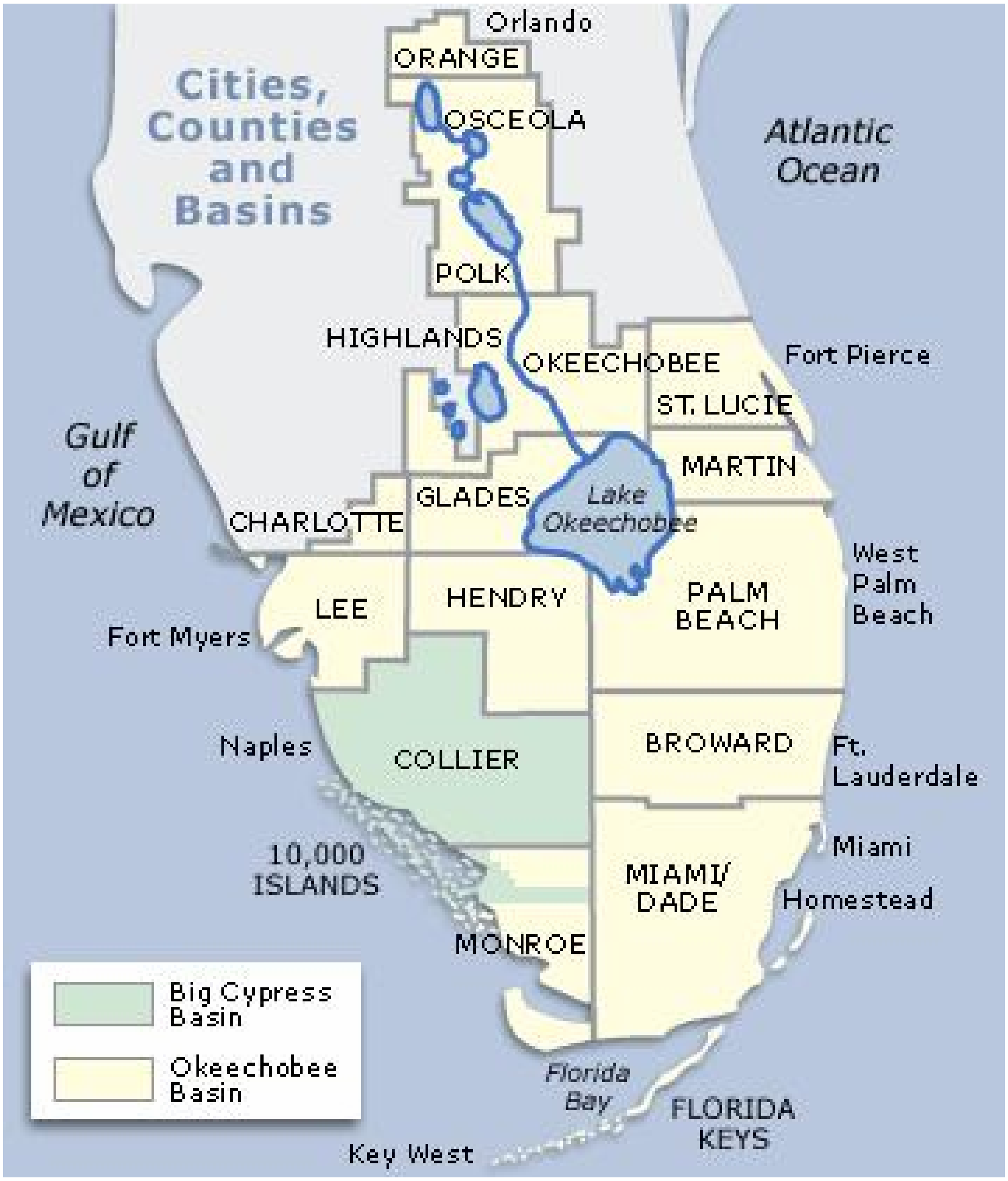
The goal of modifying the regulation schedule is to improve the health of the extensive littoral zone of Lake Okeechobee while maintaining the authorized project purposes of flood damage reduction and water supply. Economic justification of the revised operating schedule is not required. However, the economic impacts of the proposed modification of the current schedule are being estimated to aid Federal decision makers and the non-Federal sponsor in their evaluation of the alternative regulation schedules and selection of the optimal plan.

The LORSS is being conducted in close coordination with the ongoing Central and Southern Florida (C&SF) Comprehensive Review Study. The C&SF project is a system of levees, canals, and water control structures designed to provide flood control, water supply, and other services to south Florida. Lake Okeechobee is a critical element of this system. Although the C&SF project has performed its intended purposes well, it has also contributed to the decline of the south Florida ecosystem. In response to this decline, Congress authorized the C&SF study to investigate structural and operational modifications to improve: (1) the quality of the environment, (2) protection of aquifers, (3) urban and agricultural water supplies, and (4) other water-related purposes.

## 1.2 STUDY AREA

The LORSS area consists of the 16-county jurisdictional area of the SFWMD (Figure 1-1). Lake Okeechobee extends approximately 30 miles east to west and 33 miles north to south. It encompasses approximately 730 square miles (427,000 acres) at lake elevation 15.5 feet (ft.) National Geodetic Vertical Datum 1929 (NGVD), making it the second largest freshwater lake within the contiguous United States (following Lake Michigan). Although Lake Okeechobee is shallow (average depth is under ten feet) it holds an enormous amount of water, estimated at 5,106,000 acre-feet at the maximum stage under the current regulation schedule (18.5 ft. NGVD). Lake Okeechobee is surrounded by the Herbert Hoover levee system which extends

**FIGURE 1-1**
**LORSS STUDY AREA**



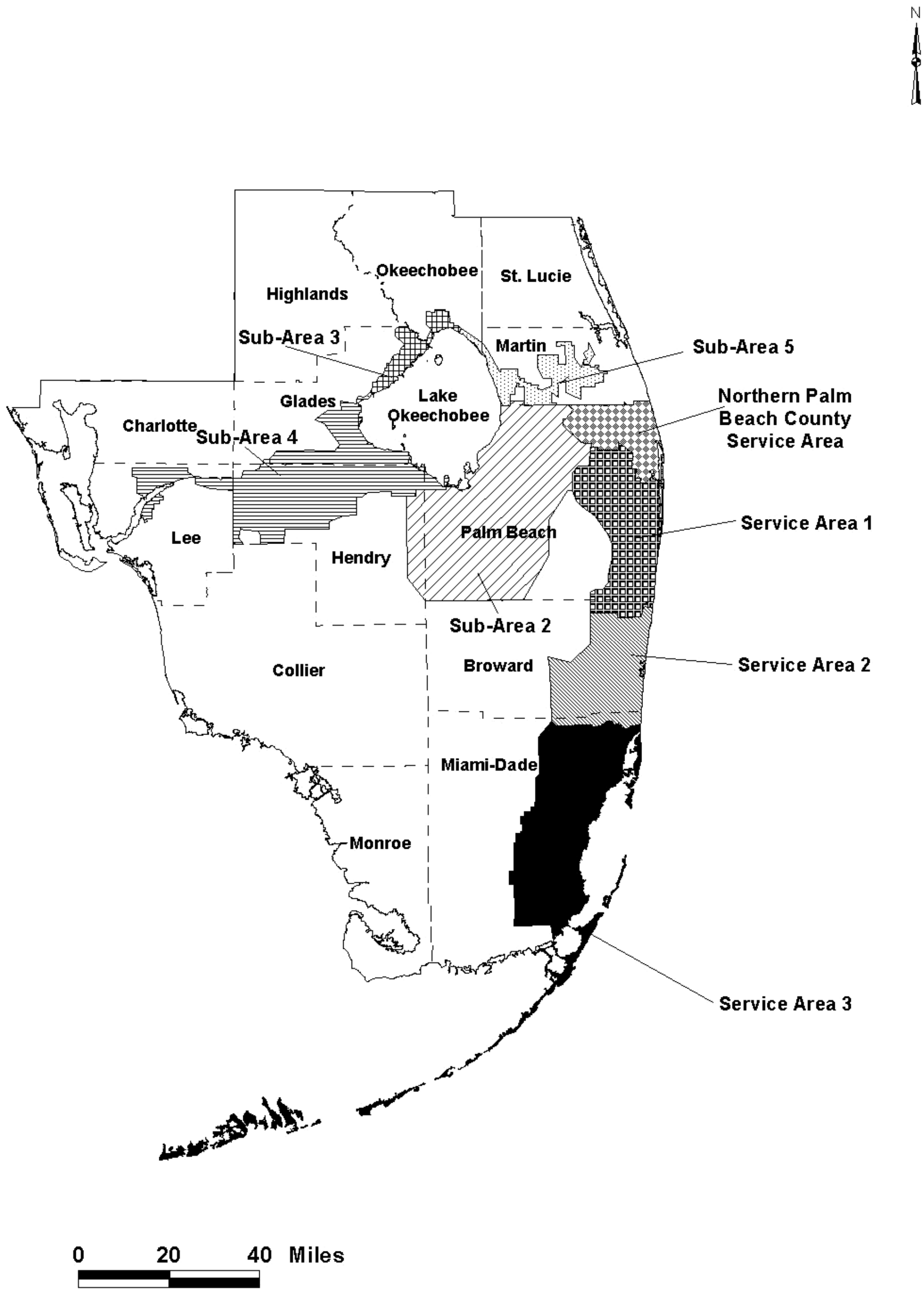

Source: South Florida Water Management District

140 miles with an average elevation of 34 ft. NGVD. The effective limit for on water supply withdrawals from the lake is 9.5 ft. NGVD due to physical limitations of the outlet structures. At this stage, Lake Okeechobee retains an estimated 1,884,000 acre-feet of water that is considered inaccessible for water supply purposes. As a result, the maximum available water reservoir storage at 17.5 ft. NGVD would be 3,222,000 acre-feet.

The principal tributary to Lake Okeechobee is the Kissimmee River, which enters the lake from the north. Other tributaries include: Taylor Creek, Nubbin Slough, Nicodemus Slough, and Fisheating Creek. Water leaves Lake Okeechobee through four principal avenues. First, in the south Florida climate, the lake loses tremendous amounts of water to evaporation, accounting for as much as 70 percent of all water losses from the lake. Second, during high lake stages, water is released eastward to the Atlantic Ocean via the St. Lucie canal. Similarly, high water releases are also made westward to the Gulf of Mexico via the Caloosahatchee River. Finally, lake water is released southward via a system of water supply structures and canals. Major water supply conduits include: the Miami, North New River, Hillsboro, and West Palm Beach canals. These canals convey water for: (1) agricultural uses in the Everglades Agricultural Area (EAA), (2) agricultural and urban water uses in the eastern portions of Palm Beach, Dade, Broward, and Monroe counties, and (3) the Everglades National Park (ENP) via the Water Conservation Areas (WCAs) located southeast of Lake Okeechobee.

Since Lake Okeechobee is so critical to water management in south Florida, the study area encompasses the jurisdictional area of the SFWMD, which includes the lake, its tributary basins to the north, and all of south Florida. However, this analysis of the potential economic effects of the alternative regulation schedules will focus on the water supply planning regions depicted in Figure 1-2, since these areas will experience the majority of the economic effects of the alternative regulation schedules. These areas include the Lake Okeechobee Service Area (LOSA) and the Lower East Coast (LEC) of south Florida. These areas are designated by the SFWMD's South Florida Water Management Model (SFWMM). They include the five sub-areas of the LOSA and the three urbanized service areas of the LEC. Referring to the sub-area designations in Figure 1-2, the five LOSA sub-areas consist of: (1) northern Palm Beach County, (2) the EAA which primarily lies within western Palm Beach County but also eastern Hendry County, (3) the northern lake district, (4) the Caloosahatchee river basin, and (5) the St. Lucie basin. The LOSA also includes two Seminole Indian reservations, Brighton and Big Cyprus, which are not shown in Figure 1-2. The three LEC service areas primarily lie within Palm Beach, Broward, and Dade counties, respectively. The water supply of Monroe County (not shown in Figure 1-2) is primarily provided by wellfields in Dade County (SA3).

**FIGURE 1-2**
**LOSA AND LEC SERVICE AREAS**




Source: U.S. Army Corps of Engineers. Central and Southern Florida Comprehensive Review Study. Plan of Study. 1997.

## 1.4 ALTERNATIVE REGULATION SCHEDULES

Four alternative regulation schedules are currently being evaluated in order to identify the optimal plan to balance the competing management objectives for Lake Okeechobee. Each alternative regulation schedule stipulates the timing, magnitude, duration, and outlets for the regulatory water releases. The regulatory schedules were primarily designed to manage the lake when water levels are high. However, the regulation of high lake levels directly affects the frequency and duration of intermediate and low lake levels, since they determine how much water is stored in Lake Okeechobee during the wet season for use during the dry season.

Achieving an optimal regulation schedule is problematic for two principal reasons. First, the large number of competing management objectives complicates the analysis. Second, the climate of south Florida presents significant water management challenges. Distinct wet and dry seasons (beginning in mid-May and mid-October, respectively) and the precipitation potential of tropical storms must be included in all management decisions regarding Lake Okeechobee.

## 1.5 METHODOLOGY

There were three considerations that dominated the development of methodologies to evaluate the economic effects of the alternative regulation schedules. First, the SFWMM provided a powerful tool to evaluate the hydrologic and economic effects of the alternative schedules. Second, to assess the effects of the alternative regulation schedules, the with- and without-project future conditions must be compared. Third, some economic effects of the alternative schedules must be estimated through economic interpretation of hydrologic and ecological effects of the alternative plans. These considerations and the resultant methodologies used in this investigation are discussed below. Additional information regarding the methodologies is provided in subsequent chapters devoted to specific categories of potential economic effects of the alternative regulation schedules.

### 1.5.1 South Florida Water Management Model

The SFWMM is the principal analytical tool being used in the LORSS to evaluate and compare the hydrologic effects of the alternative regulation schedules. The SFWMM is a regional-scale, continuous-simulation, hydrologic model that was developed by the SFWMD. It simulates the hydrology and water management of southern Florida from Lake Okeechobee to Florida Bay. As illustrated in Figure 1-3, the SFWMM spans a region that includes most of Florida south of Lake Okeechobee. Of this region, 7,600 square miles are contained in a two-mile by two-mile model grid which is used to simulate system-wide hydrologic responses to daily climatic parameters (rainfall and evapotranspiration [ET]). While some tributaries to Lake Okeechobee, such as the Kissimmee River, are included in the model, they are not simulated with the four square-mile grid cells. Similarly, the Caloosahatchee and the St. Lucie basins, both part of the LOSA, are not included in the grid. However, LOSA sub-areas to the east and south (i.e., the EAA and northern Palm Beach County) are included in the grid. Northern Palm Beach County (LOSA Sub-Area 1) is designated as LEC Service Area 4 in the SFWMM.

The SFWMM simulates infiltration, percolation, ET, surface and groundwater flows, levee underseepage, canal-aquifer interaction, current or proposed water management structures, and current or proposed operation rules. The model does not allow for changes in land use/cover and associated infrastructure for the simulation period. As a result, the simulations represent the response of a fixed structural and operational scenario to historic climatic conditions. The current version of the model includes climatic data from 1965-2000, allowing (over 11,000 sequential) daily simulations over a 36-year period.

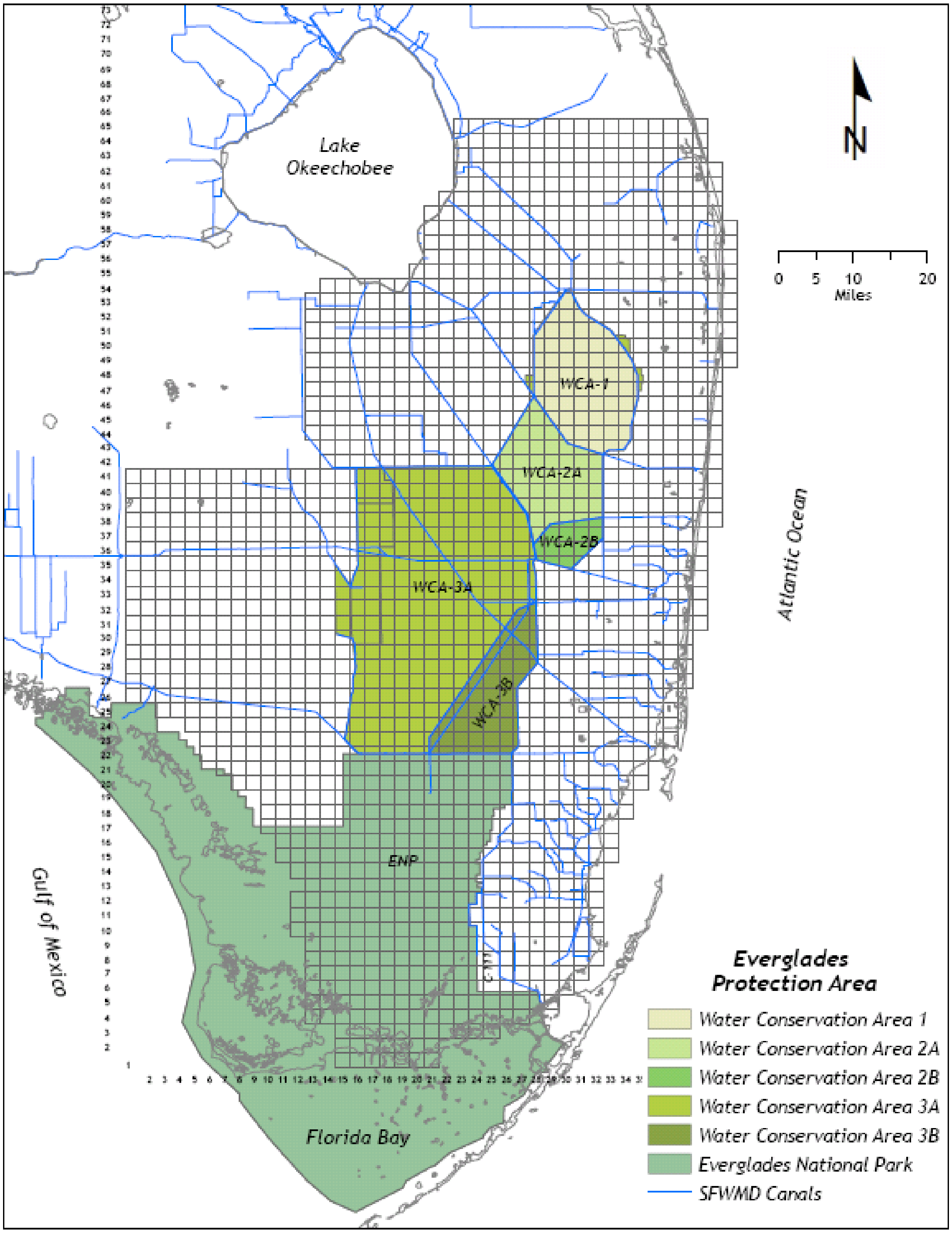
The SFWMM is an operational model whose primary purpose is to assist the SFWMD in optimizing water management and allocation decisions. The model was not designed to conduct economic analysis, but does include many indicators of hydrologic change which can have economic consequences. To assist in estimating the economic effects of water management decisions, the SFWMD developed the Economic Post-Processor (EPP) to estimate the economic effects of cutbacks in agricultural and urban water supply during drought periods. The EPP was used in the LORSS economic analysis to estimate the impacts of the alternative regulation schedules on agricultural and urban water supply.

### 1.5.2 Comparison of With and Without Conditions

The economic effects of the alternative regulation schedules were determined by comparing the with-project conditions to the current regulation schedule (i.e., the without-project condition). Using the SFWMM as the principal tool for evaluating the economic effects of alternative regulation schedules required some practical modifications to the traditional analytical procedures used in Corps water resource planning studies. In traditional feasibility studies, a probabilistic analysis is conducted to forecast conditions throughout the planning period (typically 50 years), both with and without implementation of a project. “Average annual” economic impacts are estimated by evaluating a range of possible future conditions, weighting the likelihood (i.e., probability) of these conditions by their economic effects, and then statistically combining them. The difference between “average annual” with- and without-project conditions constitutes the net annual economic impacts of the alternative plans.

This type of with- and without-project analysis had to be modified for the LORSS to account for the limitations imposed by the SFWMM. As stated previously, the SFWMM is a simulation model which equally weighs each of the days in the 36-year simulation period. It was not practical to use the SFWMM to determine the likelihood of occurrence of any given hydrologic event for two principal reasons. First, while the 36 years of past climate data are considered representative of future climate conditions, they are of insufficient duration to assign frequencies of occurrence to specific simulated hydrologic events (e.g., 25-, 50-, or 100-year return period events). Second, the regional scale of the SFWMM greatly complicates the assignment of frequencies to specific hydrologic conditions in the regional water management system.

**FIGURE 1-3**
**SFWMM BOUNDARIES**




Source: South Florida Water Management District.

### 1.5.3 Hydrologic Changes and Effects

Changing the regulation schedule for Lake Okeechobee has implications for water management throughout south Florida. The most direct effects of the alternative schedules will be on lake levels and on releases from the lake to the Everglades, to the LEC, and to tide via the Caloosahatchee River and the St. Lucie Canal. The potential economic impacts of the alternative regulation schedules are secondary consequences of hydrologic changes associated with the schedules. Figure 1-4 traces the causal linkages between the alternative regulation schedules and the different categories of economic effects.

Some categories of economic impact, such as urban and agricultural water supply effects, can be estimated directly from SFWMM-simulated hydrologic changes associated with each alternative regulation schedule plan. Other economic effects, such as commercial and recreational fishing impacts in the St. Lucie and Caloosahatchee estuaries, are less directly linked to the hydrologic changes resulting from the alternative regulation schedules. In this latter case, the chain of cause and effect includes: the impacts of project-induced changes in water release rates, the impacts of changes in release rates on the productivity of the fisheries, and the impacts of changes in the fisheries on the net income of commercial fishing operations and the quality of recreational fishing experiences. As will become evident throughout this analysis, these chains of cause and effect have important consequences for quantification of the economic effects of the alternative plans. Economic analyses cannot be applied to estimate the value of physical or ecological impacts of the alternative plans if those impacts cannot first be defined and quantified.

## 1.6 PRIOR STUDIES

The Natural Resources Conservation Service (NRCS) conducted earlier studies that supported this investigation. The NRCS was previously engaged in an interagency agreement with the Corps to perform agricultural water supply impact analyses. NRCS personnel involved in the interagency cooperation provided valuable information and insight for this study.

In addition, the SFWMD performed a series of analyses that served as inputs to this investigation. These include the Simulation of Alternative Operational Schedules for Lake Okeechobee (1998) and a series of SFWMM runs which used the economic post-processor to simulate the economic effects of water supply shortages associated with the alternative regulation schedules.

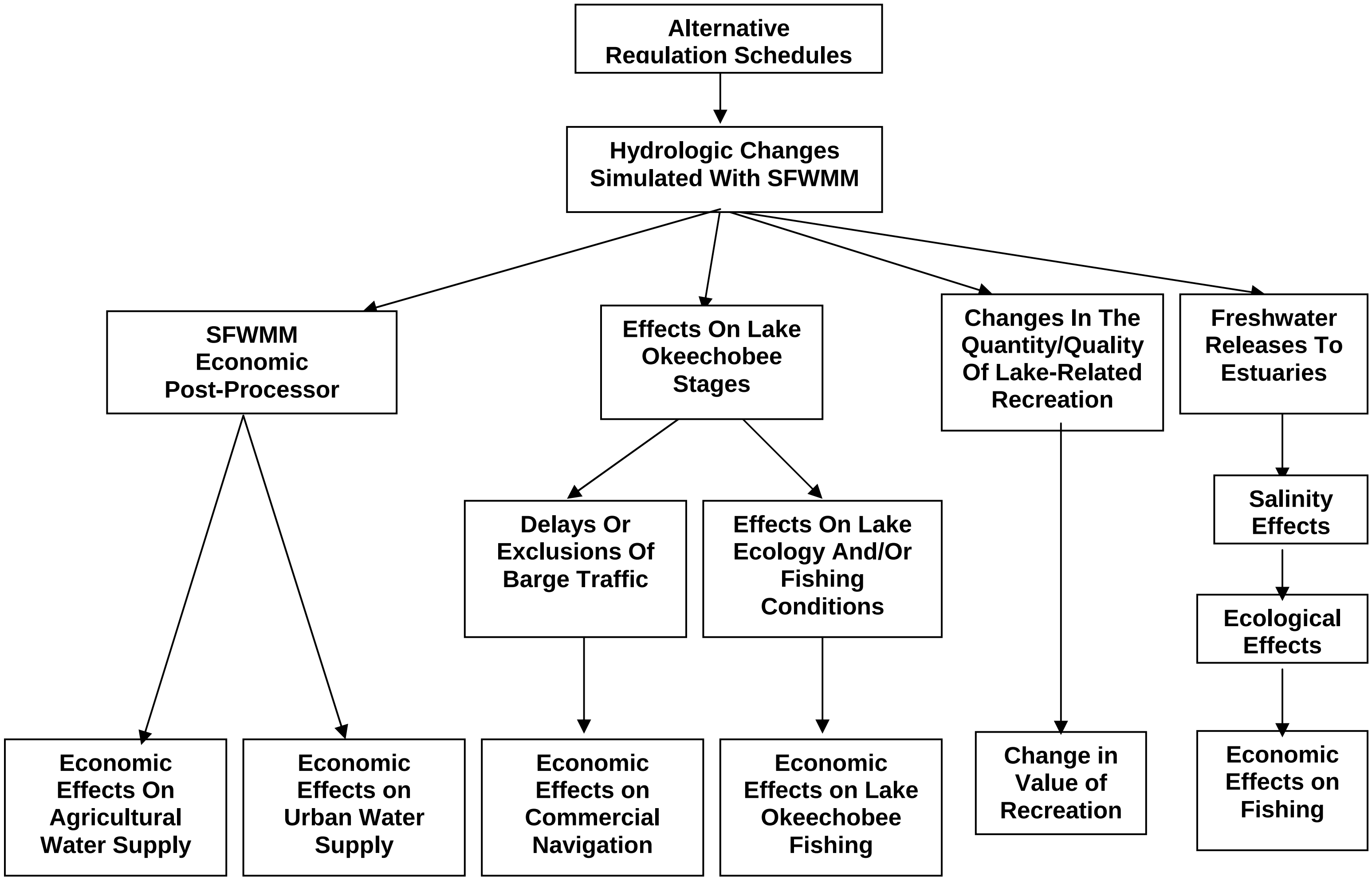



**FIGURE 1-4**
**SOURCES OF ECONOMIC EFFECTS**

# 2. AGRICULTURAL WATER SUPPLY

## OVERVIEW

Agricultural activity in south Florida is concentrated in the EAA, to the south and east of Lake Okeechobee; and in rural areas within the LEC, comprised of Dade, Broward, and Palm Beach counties. Principal crops include sugarcane, vegetables, tropical fruit, citrus, sod, ornamental plants, and nursery production. Agriculture in south Florida is supported by the region's abundant rainfall–approximately 59 inches along the LEC and approximately 49 inches in the middle of the peninsula. Unfortunately, this rainfall is not distributed uniformly throughout the year, since the region has distinct wet (May through September) and dry (October through April) seasons. During the dry season, and especially when precipitation is below normal (i.e., droughts), supplemental irrigation is required for much of the region's agriculture.

During droughts, agricultural water users have higher irrigation water demands, since ET is high and soil moisture is depleted. However, during these periods of high water demand, water supplies usually are at their lowest levels. Consequently, agricultural water users do not always receive as much water as they would like. Irrigation water shortages can have negative economic consequences for farmers, since water stress can reduce crop yields and can induce crop mortality. Residential water users in urban areas of the LEC can also experience shortages of irrigation water, which is needed for urban and suburban landscaping. These shortages can also have negative economic consequences for landscaping and can result in diminished aesthetics (i.e., brown lawns) and renovation or replacement costs for expired turf or ornamental landscaping.

The LOSA, which includes the EAA, is more dependent on agricultural water supplies from Lake Okeechobee than the LEC. During periods of normal rainfall, agricultural and urban water users in the LEC do not require supplemental water from the lake. In addition to rainfall, the LEC receives significant wellfield recharge via easterly seepage from the WCAs under the north-south levee system which serves as a boundary between the LEC and the Everglades. However, during prolonged drought events, significant volumes of water from Lake Okeechobee can be required by the LEC to supplement local water supplies and to prevent saltwater intrusion into wellfields.

The potential effects of the alternative regulation schedules on agriculture are based on the magnitude and frequency of irrigation water shortages. The economic effects of the alternative regulation schedules are the differences between the expected crop losses resulting from agricultural water shortages under with- and without-project conditions.

## 2.1 AGRICULTURE IN THE LAKE OKEECHOBEE SERVICE AREA

As described in the following profile of south Florida agriculture, there is substantial agricultural activity in the LOSA and the LEC. Two levels of detail are presented in this study regarding land uses in the EAA (the largest area within the LOSA) and the LEC. Detailed information about acreages and crop mixes from several sources is presented for the EAA and the LEC. However, the estimates of agricultural land use for the with- and without-project conditions utilize less detailed and broader land use categories for the 2000 scenarios contained in the SFWMM and EPP.

The use of broader land use categories in estimating economic effects reflects two practical considerations: (1) the need to forecast future agricultural land uses and (2) the spatial resolution of the SFWMM, which is the primary analytic tool for evaluating the alternative regulation schedules. Agricultural land uses can be extremely difficult to forecast, since crop types can change from year to year, and larger scale land use changes (such as the conversion of agricultural land to urban and suburban uses) can occur rapidly as well. As a result, it is more realistic to forecast future land uses with broad land use categories. Regarding the limitations of the SFWMM, the four square-mile resolution of the model's grid cells is coarse relative to the assessment of agricultural water supply impacts of the LORSS alternative schedules. The model was designed to simulate the hydrology of south Florida. Land use patterns in south Florida represent static inputs to SFWMM hydrologic simulations. The hydrologic implications of changes in land use can only be evaluated in this model by comparing the results of separate simulations. The SFWMM land use estimates for 2000, which are utilized in this investigation, are critical components in the analysis of with- and without-project conditions. They affect most aspects of water management in south Florida, including the economic aspects. These estimates were utilized by the economic post-processor in the runs conducted for this study and are presented below.

Table 2-1 presents the acreages of irrigated agriculture in the sub-areas of the LOSA. As indicated in this table, there are 742,668 acres of irrigated land in the LOSA. Agricultural activities in the LOSA sub-areas are described below. See Figure 1-3 for the sizes and locations of the sub-areas.

**TABLE 2-1**
**LOSA IRRIGATED ACREAGE**

| LOSA Sub-Area | Irrigated Acreage |
|---|---|
| 1. EAA | 541,878[1] |
| 2. North Shore | 13,380[2] |
| 3. Caloosahatchee Basin | 138,337[3] |
| 4. St. Lucie Basin | 49,073[4] |
| **Total LOSA** | **742,668** |

Sources:
[2] : Hall, C.A. Lake Okeechobee Supply-Side Master Plan. SFWMD. 1991.
[3] : SFWMD. Long-Range Demands for the Caloosahatchee Basin. 1997.
[4]: SFWMD. Long-Range Demands for the St. Lucie Basin. 1997.

### 2.1.1 Everglades Agricultural Area (EAA)

The EAA encompasses an area of approximately 593,000 acres. As indicated in Table 2-2, the EAA contains approximately 542,000 acres under cultivation. Sugarcane is the dominant crop type, accounting for 90 percent of the land under cultivation. The remaining 10 percent under cultivation is occupied by rice, row crops, and sod. The row crops include corn, celery, radishes, and lettuce.

**TABLE 2-2**
**AGRICULTURAL LAND USES IN THE EAA**

| Crop | Acreage | Percent of Total |
|---|---|---|
| Sugarcane | 436,856 | 86.8% |
| Miscellaneous | 18,514 | 3.7% |
| Row Crops | 21,107 | 4.2% |
| Sod | 26,912 | 5.3% |
| **Total EAA** | **493,389** | **100%** |

Sources: Hendry and Palm Beach County Tax Appraisers, 2003
[1] IFAS Extension Agent, Palm Beach County.

The EAA is very well suited to sugar production. There are thick organic muck soils and adequate water supplies from precipitation and from Lake Okeechobee via the EAA network of water supply canals. Multiple crops can be harvested from a single planting. Planting typically occurs in the autumn months. The planted cane will be ready for harvest in approximately 16 months. The root stock is left in place, and the first regrowth (i.e., ratoon) can be harvested again in 11 months. Again, the root stock is left in place, and a second ratoon will be ready in another 11 months. Some farms will harvest up to four ratoons, but yields decline with each successive ratoon. As a result, many farmers replant after the second ratoon in order to keep cane yields high.

The harvest season is from October to March. After harvesting the last ratoon, farmers must decide whether to replant immediately or leave the field fallow until the following autumn. If there is successive planting, more cane can be harvested the following year. However, if the field is left fallow, yields would be higher once the field is replanted. Many farmers will balance these competing incentives by replanting half of the field and leaving the other half fallow. For this reason, Alvarez (1997) estimates that following crop distribution would be typical of many sugarcane farms: plant cane (25%), first ratoon (25%), second ratoon (25%), fallow (12.5%), and roads, canal, ditches (12.5%). Sugarcane grown in the EAA is converted into raw sugar at the seven sugar mills found in the area. Sugarcane must be milled rapidly after it has been harvested to avoid degradation of its sugar content. The raw sugar is then shipped to sugar refineries located throughout the United States where it undergoes additional processing.

The EAA is not uniformly well suited to sugar production. In general, land that is closer to Lake Okeechobee (i.e., more northern) is better suited for sugarcane than areas to the south. The areas close to the lake are protected from frosts by the climatic influence of the lake. In addition, the muck soils are deeper in the northern part of the EAA. Consequently, soil subsidence is not as much of a problem as in areas with relatively shallow soils in the southern EAA. Subsidence occurs when the land is drained and the organic soils begin to oxidize. The surface elevation of the land subsides toward the underlying limestone bedrock. In some southern zones of the EAA, subsidence has reduced the soil layer to less than six inches, the point at which farming is typically no longer profitable. Another negative aspect of subsidence is that as the soil layer thins, the soil chemistry changes, and the application of additional nutrients (i.e., fertilizer) is required.

Most of the non-sugar crops in the EAA are grown by farmers who also grow sugarcane. Many farmers rotate their vegetable cultivation between celery and sweet corn; others rotate lettuce and sweet corn. Sod is grown primarily in the southern portion of the EAA, an area of declining suitability for sugarcane due to subsidence. Rice cultivation is small, but it could grow in importance. Rice cultivation is being encouraged by the University of Florida’s Institute for Food and Agricultural Science (IFAS) to retard soil subsidence. Rice production is also recommended by the SFWMD as way to reduce phosphorus loading into the Everglades, since rice requires less fertilizer than sugarcane. However, under prevailing market conditions rice profitability is low relative to sugarcane.

The spatial resolution of the SFWMM is too coarse to fully reflect the above land use profile of agriculture in the EAA. For example, the SFWMM assigns all of the EAA acreage to sugarcane (i.e., all of the grid cells are designated as sugarcane), since the non-sugar crops in the EAA are spatially diffuse and do not dominate a single grid cell. Therefore, only sugarcane is registered under the model’s four square-mile grid cell resolution. As a result, the information in Table 2-2 is consistent with the SFWMM land use estimates of total acreage, but not acres devoted to sugarcane cultivation. As will be evident later in this report, the model’s homogenization of agriculture in the EAA has implications for the calculation of economic impacts of the alternative regulation schedules.

The land use projections used in the SFWMM estimate that sugar cultivation (and perhaps agriculture in general) in the EAA will decrease in the future, from 529,920 acres in 1990 to 491,520 acres by 2010. The projected decrease is due primarily to the SFWMD’s purchase of agricultural land for Stormwater Treatment Areas (STAs), and perhaps to anticipated soil subsidence as well.

### 2.1.2 Caloosahatchee and St. Lucie Basins and the North Shore

Agricultural land uses for the Caloosahatchee and St. Lucie basins are presented in Tables 2-3 and 2-4. The agricultural water needs in these basins that are not met with local sources are met with water released from Lake Okeechobee into these two outlet waterways. The Caloosahatchee basin is an area of expanding agricultural activity with increasing agricultural water demands. No land use data was available for the North Shore sub-area.

**TABLE 2-3**
**AGRICULTURAL LAND USES IN THE CALOOSAHATCHEE BASIN**
**1997**

| Crop | Acreage | Percent of Total |
|---|---|---|
| Citrus | 78,113 acres | 56 % |
| Sugarcane | 50,359 acres | 36 % |
| Vegetables | 8,091 acres | 6 % |
| Sod | 1,296 acres | 1 % |
| Ornamentals | 478 acres | <1 % |
| **Total** | **138,517 acres** | **100 %** |

Source: SFWMD. Draft Long-Range Demands for the Caloosahatchee Basin. 1997.

**TABLE 2-4**
**AGRICULTURAL LAND USES IN THE ST. LUCIE BASIN**
**1997**

| Crop | Acreage | Percent of Total |
|---|---|---|
| Citrus | 43,071 acres | 88 % |
| Vegetables | 5,538 acres | 11 % |
| Sugar Cane | 449 acres | 1 % |
| Nursery | 15 acres | <0.1 % |
| **Total** | **49,073 acres** | **100 %** |

Source: SFWMD. Draft Long-Range Demands for the St. Lucie Basin. 1997.

## 2.2 AGRICULTURE IN THE LOWER EAST COAST

The three service areas of the LEC also contain large areas of agriculture. Table 2-5 presents the 1990 and 2010 agricultural land use patterns contained in the SFWMM for the LEC service areas, including northern Palm Beach County (SA-4). These values were extracted from the SFWMM by the economic post-processor. The post-processor considers only those SFWMM land use categories for which economic effects of water shortages can be generated. As indicated in Table 2-5, the post-processor uses six broad categories of land use: urban, nursery, golf courses, low-volume (LV) irrigated agriculture (such as citrus and avocado), overhead (OV) irrigated agriculture (such as tomatoes), and other agriculture (including sod, sugarcane, and rice). As suggested in this table, tomatoes are intended to represent truck vegetables grown with OV irrigation systems. The categories of urban (turf) and golf (which is primarily suburban) land uses are included because these lands are maintained with irrigation water that is supplemented directly or indirectly with water from the regional water supply system. While these two land uses are not agricultural, they will be included in the discussions of agricultural water supply throughout this report.

## 2.3 AGRICULTURAL WATER MANAGEMENT DURING SHORTAGES

To estimate the potential damages associated with shortages in agricultural water supply, it is necessary to understand how irrigation water supplies are managed during drought periods. Agricultural water use during droughts is the result of regional decisions made by water management institutions, such as the SFWMD, and local decisions made by water users, including individual farmers. These two levels of water management decision making during droughts are discussed below.

### 2.3.1 Regional Water Management

The SFWMD monitors hydrologic conditions throughout south Florida. Current hydrologic and water use data is compared to historic data to determine: (1) whether present and anticipated water supplies are sufficient to meet the present and anticipated needs of water users and (2) whether serious harm to the region's water resources can be expected, including saltwater intrusion into freshwater aquifers or adverse fish and wildlife effects.

Factors considered in estimating present and anticipated water supplies include:

- Historic, current, and anticipated levels in surface and ground waters,
- Historic, current, and anticipated flows in surface waters,
- The extent to which water may be transferred from one source to another,
- The extent to which water use restrictions might enhance supplies,
- Historic, current, and anticipated demands of natural systems, and
- Historic, current, and anticipated seasonal fluctuations in rainfall.

Factors considered in estimating present and anticipated water demands include:

- Estimated current, and anticipated demands of permitted and exempt users,
- Demands of users whose water supply is established by Federal law,
- Anticipated seasonal fluctuations in user demands, and
- The extent to which user demands may be met from other sources.

When the current or future water supplies are not expected to meet water demands, the SFWMD may institute a series of progressively more severe conservation (demand management) measures to conserve water supplies. The SFWMD developed the Water Shortage Plan in 1982 following a severe drought during which Lake Okeechobee reached its all-time record low level of 9.75 ft. NGVD. The plan provides specific guidelines for water restrictions, which are based on the type of use and the severity of the drought. Included within the plan are four progressively more severe water shortage phases (I-IV) which initially request and later require cutbacks in water use throughout south Florida. Included within the Water Shortage Plan are water use reductions which are expected to range up to 15 percent of estimated demand under Phase I and up to 60 percent of estimated demand under Phase IV.

Shortage declarations by the SFWMD can be triggered by salinity intrusion into coastal aquifers threatening utility wellfields or by low lake levels in Lake Okeechobee relative to seasonal norms. The declarations are typically continued until it is clear that the imbalance between water supplies and water demands is resolved, avoiding to the extent possible an on/off whipsaw of shortage declarations.

If droughts are localized, the SFWMD will attempt to manage the regional water supply system to move water from areas of surplus to areas of deficit. The shortage phase declarations can be scaled to the municipal, utility, county, service area, or regional level commensurate with the extent of the water shortage. For regional droughts, such as those triggered by low Lake Okeechobee levels, the water shortage phases are instituted to reduce water demand on a system-wide basis. To date, the specific use restrictions of the Water Shortage Plan have been invoked three times: 1982, 1985, and 1989 (Hall, 1991).

The four phases of water supply shortages in the Water Shortage Plan stipulate cutbacks by water users in the LEC, including agricultural water usage. However, the phased restrictions in the Water Shortage Plan have not been applied to agriculture in the LOSA. Agricultural water users in the LOSA are subject to SSM for Lake Okeechobee. The required agricultural water use restrictions of the Water Shortage Plan are assumed to have been met when LOSA water users comply with Lake Okeechobee's SSM plan.

During severe droughts, water levels in Lake Okeechobee drop as inflows are exceeded by water losses from releases and evaporation. If water levels fall sufficiently, SSM is instituted for the Lake Okeechobee. The amount of water available for use is a function of anticipated rainfall, evaporation, and water needs (for the balance of the dry season) in relation to the amount of water currently in storage. SSM begins when lake levels fall below the watch and warning levels and enter Zone A. The upper limit of Zone A represents a storage amount sufficient to meet all demands in the following year provided that all basins receive at least 100 percent of normal rainfall during the year. Each of the zones represents storage levels with assigned probabilities of shortage. For example, if the stage in the wet season is in Zone A or lower, the area has a 50 percent probability of a water shortage in the following winter and spring (i.e., dry season).

The SFWMM is used to calculate weekly water allocations for each agricultural water user in the LOSA. Available water supplies are estimated based on lake levels and evaporation and rainfall estimates. Allocations are then made by comparing normal water requirements with available water supplies.

The SSM rules for the EAA are bounded by SFWMD policy which commits to supplying a minimum of one-third of the supplemental irrigation needs for agriculture in this area. This lower limit of agricultural water supply is reflected in the SFWMM. This policy may effectively preclude crop mortality in the EAA during dry periods and limit drought effects on agriculture to reduced crop yields.

### 2.3.2 Local Water Management

For each crop and irrigation method in the LEC, the water use of farmers is specified by the Water Shortage Plan. Farmers in the LOSA have more flexibility in making water management decisions. Under SSM, water allocations to agricultural users in the LOSA are progressively cutback as shortages become more severe (Zones A to D). However, the SFWMD Governing Board may allow agricultural users to borrow against their seasonal allocation in the first four months of the dry season. The behavior of LOSA farmers in the face of water supply shortages is based on the vulnerability of their particular crops to water stress and the value of those crops. If plants do not receive sufficient moisture from precipitation or irrigation, particularly during critical stages in the growing season, ET is reduced, and growth rates and yields can be significantly affected. Some crops are more vulnerable to water stress than others. For example, sugarcane is more tolerant to water stress than most vegetables. As a result of water stress, the sugar content of the cane will be reduced, but the entire crop will not be lost. In fact, some sugar farmers prefer dry conditions immediately prior to harvest, since it increases the sugar content of the cane. Vegetables, on the other hand, can quickly suffer large yield effects and crop mortality in response to stress from water shortages.

Changes in crop yield are a critical determinant of farm income and can induce changes in crop mix or farming practices. For farmers in the EAA who grow sugar and vegetables, their decision making during water shortages is based on expected crop-specific responses to water stress and the relative value of each crop. Farmers will allocate water on their lands based upon the greatest marginal value of the scarce irrigation water. When water allocations from the regional water system are reduced, farmers will typically give vegetables priority over sugar cane (Scheneman, 1997), because of the sensitivity and value of vegetable crops. As a result, vegetables and other non-sugar crops in the EAA are not expected to experience as great a cutback during shortages, since sugarcane will be the primary recipient of irrigation cutbacks.

Interviews conducted with a variety of experts on EAA agriculture indicate that farmers will generally borrow as much water as they can against their future allocation in order to fully satisfy the water needs of their crops for as long as possible (Personal Communications: Alvarez, 1997; Scheneman, 1997). Essentially, farmers in the EAA will accept the risk of extreme cutbacks later in the season in order to meet their full irrigation needs early in the season. Farmers weigh their present needs against their future needs with careful consideration. The type of crop, timing during the growing season, and anticipated cutbacks are included in their decision making. This risk-accepting behavior is supported by experience. During the 1981-1982 drought, widespread borrowing against seasonal water allocations by farmers in the EAA was reinforced by above-normal rainfalls later in the growing season, mitigating the deferred impacts of the drought (Hall, 1991). The SFWMD's policy of meeting at least one-third of the supplemental irrigation requirements of farmers in the EAA may give additional impetus for farmers to borrow against their seasonal water allocations.

Reductions in delivery of water from Lake Okeechobee to south Florida agriculture may or may not result in economic losses to farmers. The 1981-1982 experience cited above is testament to this uncertainty. There are a variety of factors which determine the actual economic impacts of shortages, including antecedent conditions, local precipitation during and after the cutbacks, crop types, and the timing of the cutbacks with respect to the growing season. Interviews with LOSA agricultural experts also suggest that farmers will not significantly modify their production activities during shortages. When shortages do occur, the water stress associated with irrigation cutbacks will result in yield reductions for the entire crop, since water stress will be uniform across the entire irrigated area. Therefore, the unit costs of crop production will not change significantly for different yield levels. Regardless of whether the crop is 100 percent, 80 percent, or 50 percent of potential yield, the unit costs of crop production will be the same. As will be evident later in this report, this has important implications for estimating the NED impacts of agricultural water supply shortages resulting from the alternative regulation schedules.

## 2.4 ECONOMIC POST PROCESSOR DEVELOPMENT AND FUNCTION

The SFWMD has developed an EPP to assess the monetary effects of agricultural and municipal and industrial (M&I) water supply shortages. The EPP, which is embedded in the SFWMM, was designed to estimate the agricultural and M&I water supply impacts of physical or operational changes in water management in south Florida, such as modifying the regulation schedule for Lake Okeechobee. The utility of the EPP for estimating the potential economic effects of the alternative regulation schedules is examined below.

The EPP was originally developed to estimate the benefits of structural and/or operational improvements to the regional water supply system by monetizing the value of south Florida's unmet demands for agricultural and municipal & industrial (M&I) water supply. As illustrated in 1246Figure 2-4 and described below, the agricultural element of the EPP was developed through a five-part process.

### 2.4.1 Development of the AFSIRS Model

The Agricultural Field Scale Irrigation Requirement Simulation (AFSIRS) was developed at the Agricultural Engineering Department of the University of Florida (Smajstrla, 1990). This model predicts water requirements for maximum crop yields. It does not predict crop yields, but instead calculates the quantity and frequency of irrigation necessary to avoid water stress to crops. The program contains the data necessary to model all of the commercially important crops in Florida under various irrigation schemes and with a wide variety of soil types.

AFSIRS calculates irrigation requirements and ET rates as a function of crop type, soil type, irrigation system, growing season, and climatic conditions. The model assumes that irrigation requirements are met from the unsaturated zone through rainfall or supplemental irrigation. As illustrated in Figure 2-4, the model draws upon four data files. The user specifies three sets of input parameters for the agricultural plot: soils, crops, and irrigation systems. These inputs are combined with time-series precipitation data and simulated potential and crop-specific ET and potential ET PET) rates respectively. The model then calculates how much water is required by the selected crop at a particular point in its growing season under specific soil and climatic circumstances. AFSIRS has been successfully tested and applied in south Florida. The SFWMM contains an AFSIRS module that is used to estimate daily water requirements of irrigated agriculture in the LOSA and the LEC.

### 2.4.2 Modification of the AFSIRS Model for Drought Applications

Thompson and Lynne (1991) of IFAS modified the AFSIRS program for drought impact analysis. Among the modifications made by Thompson and Lynne was the introduction of the Stewart equation into the model. The Stewart equation relates the difference between actual ET and PET to changes in crop yield. The logical basis for the Stewart equation is that plants reduce their transpiration when they are water stressed, and this reduction is an indicator of stress-induced effects on crop yield. The Stewart equation is as follows:

$$1-(Y_{act}/Y_{max}) = \beta(1-ET_{act}/ET_{max})$$

where:

| | |
|---|---|
| $Y_{act}$ | = actual crop yield per acre (simulated) |
| $Y_{max}$ | = maximum crop yield per acre |
| $\beta$ | = crop specific output per irrigation level (Beta coefficient) |
| $ET_{act}$ | = actual evapotranspiration per acre (simulated) |
| $ET_{max}$ | = potential evapotranspiration (PET) |

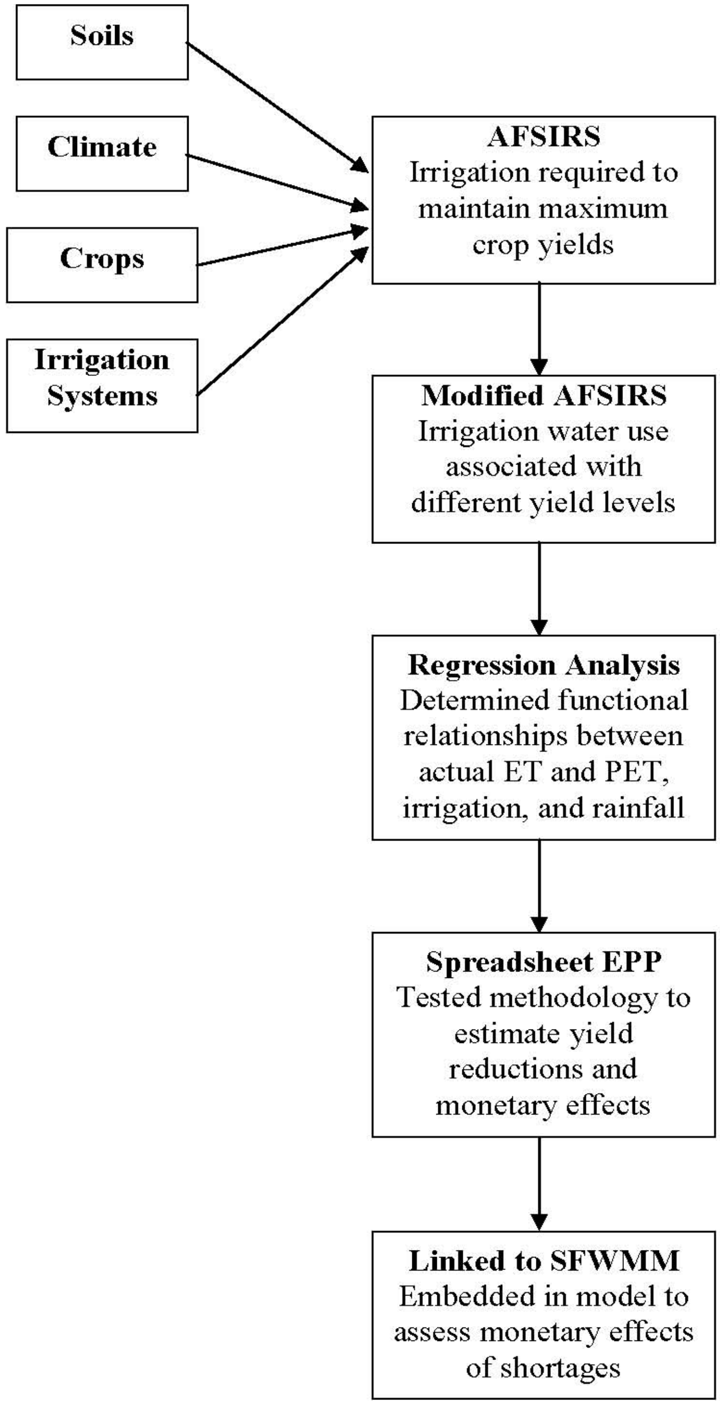



**FIGURE 2-4**
**DEVELOPMENT OF THE AGRICULTURAL ELEMEMT**
**SFWMM ECONOMIC POST-PROCESSOR**

According to Thompson and Lynne, the Stewart equation is widely accepted. The crop-specific Beta coefficients (□), which relate water stress to crop yields, are based on research conducted for the Food and Agricultural Organization of the United Nations (Doorenbos and Kassam, 1979). The Beta coefficients depend on the crop type and growth stage being modeled. Thompson and Lynne caution users of this model that the Beta coefficients contained in the program have been obtained from experimental data. For annual crops, single coefficients are included in the model for four growth stages: early vegetative, flowering, yield formation, and ripening. For perennials, it is more difficult to produce coefficients for specific growth periods. For example, it is well known that citrus is sensitive to water shortages during flowering. However, the actual flowering period will vary with climate and with soil moisture. This is problematic for AFSIRS, since it calculates irrigation requirements using the calendar date as a key to crop growth stage.

In the modified AFSIRS program, the user must specify actual yields ($Y_{act}$) as a proportion of the unconstrained yield ($Y_{max}$). The model uses the Stewart equation to simulate actual ET ($ET_{act}$). In the model, $ET_{act}$ is drawn from the unsaturated zone, and the water comes from rainfall or supplemental irrigation. Precipitation estimates contained in the climatic data file are used by the modified AFSIRS program to compute the supplemental irrigation required for the specified crop yields.

Thompson and Lynne (1991) attempted to validate the modified AFSIRS program. This was problematic however, since there were no subsequent agricultural droughts with which to compare the model's predictions. Instead, the model was tested against three crop-growth models which have been tested extensively in north Florida. The modified AFSIRS model generated results which were similar to the other models. Improvements were subsequently made to the model during the calibration process.

### 2.4.3 Regression Analysis

The SFWMD used the modified AFSIRS to determine the functional relationships between actual ET and PET, irrigation levels, and precipitation for a wide variety of crop and irrigation schemes (March, 1996). This was done by performing a series of model runs, specifying a range of different actual yields ($Y_{act}$): 100%, 75%, 60%, 50%, 40%, and 25%. This generated a series of simulated $ET_{act}$ values. Regression equations were then computed to relate modeled monthly ET to monthly PET, rainfall, and net irrigation. The general functional form of the regression equations is double (natural) logarithmic:

$$\ln (ET_{ijkl}) = \alpha + \beta_1 \ln (PET_i) + \beta_2 * \ln (Raadj_i) + \beta_3 * \ln (Iradj_{ijkl})$$

where:

$ET_{ijkl}$ = actual ET in month i of crop j on soil type k for yield level l
$PET_i$ = Modified Penman-Monteith potential ET in month i
$Raadj_I$ = measured rainfall in month i
$Iradj_{ijkl}$ = simulated net irrigation in month i of crop j on soil type k at yield level l

(Note: $\beta_i$ here are regression coefficients, not the crop output factors in the Stewart equation)

### 2.4.4 Spreadsheet Prototype

The SFWMD developed a spreadsheet prototype of the EPP. During periods when available irrigation water supplies are less than what the AFSIRS model predicts is necessary to support maximum crop yields, the EPP estimates the potential reduction in agricultural revenues using the functions described above. The lower crop yields estimated using the regression functions are compared against maximum yields to determine changes in yield per acre. These values are then multiplied by the number of acres to estimate changes in total crop outputs. Crop outputs are multiplied by market prices to compute the potential revenue effects of water shortages.

### 2.4.5 Linkage to SFWMM

Once the spreadsheet prototype was successfully tested, the SFWMD embedded the EPP within the SFWMM. The SFWMM outputs of PET, irrigation water supply, and precipitation were combined with the land use profile (agricultural) for input to the EPP. The AFSIRS module determines the irrigation requirements for specific crops in particular locations. When irrigation water supply is insufficient to meet crop requirements, the EPP estimates the potential reduction in total revenues which could result from water shortages.

## 2.5 EPP ASSESSMENT

The EPP model has some theoretical and experimental components. When the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) was supporting the Corps in its attempt to estimate the effects of the alternative regulation schedules on agricultural water supply, the staff considered using historical data to develop crop-specific relationships between crop yields and irrigation water shortages. The NRCS reviewed the past 25 years of agricultural water supply data available from the SFWMD and compared this information with historic data on crop yields in south Florida. According to NRCS staff, there was only one drought year during this period (i.e., 1982) when there was a significant shortage of irrigation water in south Florida. During this year, crop yields were significantly lower than other years. However, during this year there was also a freeze that resulted in substantial crop damage. Unfortunately, it was not possible to distinguish the effects of the freeze from the effects of the drought.

The EPP was reviewed to assess its suitability for estimating the NED effects of the LORSS regulation schedule alternatives on agricultural water supply. All five developmental elements illustrated in Figure 2-4 were examined. First, available AFSIRS documents were reviewed to determine its purpose, function, assumptions, strengths, and shortcomings (Thompson and Lynne, 1991). Second, a copy of the modified AFSIRS program for drought impact analysis was obtained from the SFWMD, including input data files, a copy of the computer code, and supporting documentation. Test runs of the modified program were made to evaluate program inputs, function, and outputs. Third, the documentation of the regression analyses that were conducted to develop the functional relationships between simulated $ET_{act}$ and PET, precipitation, and irrigation was reviewed. In addition, SFWMD personnel (Dr. Richard March) involved in developing the EPP were interviewed. Fourth, the spreadsheet prototype of the EPP was examined and tested to evaluate the logic underlying the calculation of the monetary effects of agricultural water shortages. Finally, the draft documentation for the SFWMM was reviewed to determine: (1) the outputs from the model used by the EPP and (2) the function of the

AFSIRS module within the SFWMM. In addition, the output files from the EPP runs conducted for this investigation were scrutinized to determine how the EPP interacts with the SFWMM.

Based upon our review of the EPP-related materials, the post-processor seems to be a logical and practical approach to a difficult problem (i.e. estimating changes in crop yields and revenues associated with irrigation water shortages). However, there are four categories of issues that qualify the use of the economic post-processor. These issues do not preclude using the EPP to estimate the NED effects of the regulation schedule alternatives on agricultural water supply, but they qualify interpretation of its outputs.

### 2.5.1 Crop Response

The agricultural science that underlies the AFSIRS model is in its infancy. However, the program has been tested by the SFWMD, and calibrated for use in the SFWMM. The Beta coefficients used in the Stewart equation are less evolved and should be considered experimental at this time. Additional research is needed to refine these coefficients. This research could determine the sensitivity of crop yields and revenue effects to changes in Beta coefficients. The most useful validation of the drought model would be to test it against empirical data from an actual drought event.

It is unclear whether the yield reductions predicted by the modified AFSIRS model imply crop mortality or, in the case of perennials (e.g., citrus), long-term damage that may affect future crop yields. Crop mortality would probably be limited to severe water shortages, but these events may comprise a significant share of potential revenue effects of water shortages. However, as noted previously, the SFWMD has a policy that commits Lake Okeechobee water supplies sufficient to meet at least one-third of the supplemental irrigation needs of EAA farmers. This minimum irrigation level may prevent extensive crop mortality in the EAA during droughts.

### 2.5.2 Growing Season

The timing of agricultural water supply shortages during the growing season is a critical factor in determining the extent and severity of potential crop losses. The difficulty of applying specific Beta coefficients to particular growth stages was mentioned earlier. In the EPP, the user specifies the start and end months for the growing season for each crop. The simulation of revenue effects is based upon estimates of yield reductions that would result from water shortages during the specified months. If the actual growing seasons are not well aligned with the modeled growing seasons, the accuracy of the simulation could be compromised. The climate of south Florida is problematic in this regard, since it allows more flexibility in planting and harvesting than more northern climates.

There is an additional complication associated with crop rotation. As described previously, it has been estimated that approximately 12.5 percent of the land under sugarcane cultivation is fallow at any given time. If this is true, that would remove over 60,000 acres of sugarcane cultivation from vulnerability to water shortages. The EPP does not take crop rotation into consideration and therefore may overestimate the potential damages associated with water shortages. Land rotation considerations might also be important for other crops, as well.

### 2.5.3 SFWMM Constraints

The SFWMM provides tremendous analytical power for evaluating the regulation schedule alternatives. However, there are some model-related constraints that affect its use in estimating the economic effects of agricultural water shortages. First, the land use categories in the SFWMM are broader than those used by the EPP. The AFSIRS program is able to accommodate many different crop types and soil varieties not modeled in the SFWMM.

Second, the spatial resolution of the SFWMM model is too coarse to accurately assess the agricultural impacts of the regulation schedule alternatives with great confidence. For example, the SFWMM does not recognize crops other than sugar in the EAA, since none of the four square-mile grid cells are dominated by non-sugar crops. In actuality, there are 40,000 acres of non-sugar crops in the EAA.

In addition, the model presents a single value for soil depth in a grid cell. In the EAA, the depth of the soil is a critical factor in assessing the drought vulnerability of sugarcane. A single value (i.e., model node) for an area of four square miles may mask significant differences in drought vulnerability for the same crop. Finally, the model must make assumptions about the behavior of farmers in the LOSA during extended dry periods. The ability of farmers to borrow water early in the dry season creates significant uncertainty regarding the timing and effects of water shortages.

### 2.5.4 Prolonged Water Shortages

The EPP calculates crop yield effects on a monthly basis. For shortages of several months duration, the EPP may overestimate the effects on crop yield and revenue because each month is treated independently in the EPP. An example may best explain how an overestimate may occur. If there was a water shortage of 20 percent during the first month of the shortage, crop yields might be reduced by ten percent. If the same shortage persisted to the following month, the crop yield effects would again be calculated at ten percent. At the end of the year, the shortage would be tallied by the model as reducing crop yields by 20 percent. However, a 20 percent shortage sustained over two months might actually result in less than a 20 percent reduction in annual yield. Even if the ten percent value for the second month was correct, it should probably be discounted (i.e., applied to the 90 percent of yield remaining after the first month of the shortage). One possible way to address this issue would be to treat shortages with durations of multiple months as a single event, evaluating the aggregate water shortage and applying that percentage to the maximum crop yield.

## 2.6 POTENTIAL NED EFFECTS ON AGRICULTURAL WATER SUPPLY

The NED account should reflect changes in net farm income that are associated with reduced agricultural water supply. According to the SFWMM analyses, the alternative regulation schedules will have different effects on agricultural water supply in the study area and thereby have different impacts on farm incomes. For the LORSS, the determination of NED effects on agricultural water supply requires a four-part process. First, the available water supplies are estimated for each alternative plan. Second, the supplies of the alternative plans are compared to water demand forecasts to identify potential shortfalls in water deliveries. Third, identified shortages are translated into dollar-value reductions in net farm income. Finally, the monetary costs of water supply shortages of each alternative plan are compared to the costs anticipated in the absence of any action (i.e., comparing the with- and without-project conditions) to estimate the net economic effects of the alternative plans. The first two steps have been accomplished in the SFWMM using the model's 36-years of daily simulations. The third and fourth steps are addressed below.

### 2.6.1 Revenue And Income Effects

The economic effects of changes in agricultural water supply can be registered in the NED account if there are resulting changes in either crop damages or land use. No land use effects are anticipated for the Restudy, since implementation of any of the alternative restoration plans is not expected to induce any changes in crop patterns. Therefore, the potential NED effects of changes in agricultural water supply are estimated based upon expected changes in net farm income during drought conditions. The NED account should include the net farm income effects associated with changes in both revenues and production costs resulting from plan implementation.

For sugarcane and non-sugar crops, the cost of crop inputs incurred over the course of the growing season would not change during shortages. The potential income effects of water shortages would therefore be derived from changes in harvesting and transportation (to processing facilities) costs. For sugarcane, harvesting and transportation in the EAA are conducted by the sugar mills, which then deduct these costs from their payments to the farmers for the cane. Sugarcane harvesting costs would not be expected to change during shortages for two reasons. First, while shortages would reduce sugarcane yields, it is assumed that the SFWMD will provide sufficient irrigation water supplies to avoid crop mortality. As a result, the same area would be harvested during shortages as during non-shortage periods, since sugarcane is drought-tolerant. Second, since sugarcane harvesting is entirely mechanized, the combines would harvest the same areas during shortages with costs identical to non-shortage periods.

Under water stress, sugarcane yields in terms of biomass are reduced. Consequently, reductions in transportation costs to the sugar mills are expected. Given the relatively small shortage-induced changes in transportation costs anticipated for sugarcane and the inherent difficulty in quantifying them, it can be assumed for practical purposes that changes in farm revenues are approximately equal to changes in farm income. However, the exclusion of changes in sugarcane transportation costs during shortages may slightly exaggerate reductions in farm income associated with water shortages.

For vegetables and other non-sugar crops in the EAA, the assumption that changes in revenue equal changes in income is valid for other reasons. In the EAA, non-sugar crops such as rice, sod, and truck vegetables are raised by sugar farmers as supplemental crops. Based upon interviews with experts on EAA farm practices, it appears that during shortages, these crops would have irrigation priority over sugarcane. These crops are high-value relative to cane, and they are much more vulnerable to water shortages.

In the LEC, the assumption that changes in revenues would equal changes in income would not be applicable to non-sugar crops (i.e., row crops and citrus). There would be some reductions in harvesting costs, as well as reductions in transportation costs. However, most of the effects of agricultural water shortages in the LEC are associated with urban landscaping and golf land uses, not commercial agriculture. Consequently, the assumption that changes in revenues equal changes in farm income remains valid for agriculture in the LEC, as well as in the EAA.

### 2.6.2 Agricultural Water Supply in the EAA and LEC

Table 2-5 contains the SFWMM-simulated revenue (and income) effects on agriculture in the EAA and LEC associated with the current regulation schedule and the five alternative schedules. The values contained in this table represent the values of unmet demand for agricultural water supply, translated into income losses using the EPP. The value of unmet demand is defined as the difference between maximum possible yields under unconstrained water conditions and the yields predicted by the model for each regulation schedule. Therefore, the higher the value of unmet listed in the table, the greater the reduction in potential yields (and revenue losses) imposed by each alternative. Alternative regulation schedules with lower unmet demands than existing conditions indicated decreased crop losses (i.e., improved conditions).

The values in the table represent simulated income losses from agricultural water supply shortages during the 36-year simulation period. The value includes the estimated demands not met for urban (turf) and golf (turf) land uses, as well as agricultural crops. The average annual values are arithmetic averages of total income effects distributed over the 36 years. As indicated in this table, three of the alternative regulation schedules (Alternative 2A, 2A_M and 4) result in the greatest unmet demand for agricultural water beyond that of the current schedule. The other two alternatives (1bs2 and 1bs2_m) are expected to meet agricultural water demands more effectively.

**TABLE 2-5**
**VALUE OF UNMET DEMAND FOR AGRICULTURAL WATER SUPPLY EAA AND LEC ($2005)**

| Scenario | Area | Total 2000 | Average Annual 2000 |
|---|---|---|---|
| 2007LORS | EAA | $1,435,118 | $39,864 |
| 2007LORS | SA1 | $0 | $0 |
| 2007LORS | SA2 | $0 | $0 |
| 2007LORS | SA3 | $0 | $0 |
| 2007LORS | SA4 | $0 | $0 |
| 2007LORS | **Total** | **$1,435,118** | **$39,864** |
| 1bs2 | EAA | $4,204,315 | $76,922 |
| 1bs2 | SA1 | $0 | $0 |
| 1bs2 | SA2 | $0 | $0 |
| 1bs2 | SA3 | $0 | $0 |
| 1bs2 | SA4 | $0 | $0 |
| **1bs2** | **Total** | **$4,204,315** | **$76,922** |
| 1bs2_m | EAA | $4,482,064 | $84,637 |
| 1bs2_m | SA1 | $0 | $0 |
| 1b22_m | SA2 | $0 | $0 |
| 1bs2_m | SA3 | $0 | $0 |
| 1bs2_m | SA4 | $0 | $0 |
| **1bs2_m** | **Total** | **$4,482,064** | **$84,637** |
| 2a | EAA | $8,370,800 | $192,657 |
| 2a | SA1 | $0 | $0 |
| 2a | SA2 | $0 | $0 |
| 2a | SA3 | $0 | $0 |
| 2a | SA4 | $0 | $0 |
| **2a** | **Total** | **$8,370,800** | **$192,657** |
| 2a_m | EAA | $9,240,759 | $298,089 |
| 2a_m | SA1 | $0 | $0 |
| 2a_m | SA2 | $0 | $0 |
| 2a_m | SA3 | $0 | $0 |
| 2a_m | SA4 | $0 | $0 |
| **2a_m** | **Total** | **$9,240,759** | **$298,089** |
| 4 | EAA | $6,511,896 | $141,022 |
| 4 | SA1 | $0 | $0 |
| 4 | SA2 | $0 | $0 |
| 4 | SA3 | $0 | $0 |
| 4 | SA4 | $0 | $0 |
| **4** | **Total** | **$6,511,896** | **$141,022** |

# 3. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

## OVERVIEW

The hydrologic effects of the alternative regulation schedules also have implications for M&I water supply. In the LORSS area, most of the M&I water use is in the three service areas of the LEC. If water demands exceed supplies, shortages may result, and cutbacks may be imposed by the SFWMD.

As outlined in the previous chapter, the SFWMD's Water Shortage Plan curtails water use in south Florida using a four-phase progression of increasingly severe restrictions: Phase I (Moderate), Phase II (Severe), Phase III (Extreme), and Phase IV (Critical). Cutbacks in the first two phases are primarily voluntary. In the more severe shortages (Phases III and IV), mandatory use restrictions are imposed. The cutbacks imposed by the plan affect residential, commercial, and industrial water users. The restrictions on M&I water use during shortages have associated opportunity costs. The economic impacts of the alternative regulation schedules are the differences between the without-project costs associated with the current regulation schedule and the with-project costs associated with the alternative regulation schedules.

Whether voluntary or mandatory, shortages of M&I water supply (i.e., agricultural shortages) can have significant economic implications. There may be direct costs associated with active conservation measures (i.e., reducing water use during shortages), particularly for residential and commercial water users who may experience opportunity costs as a result of reduced supplies, affecting water-related activities such as watering lawns and washing cars. If shortages are frequent, there may be M&I costs associated with developing new sources of supply, increased treatment costs, and/or instituting passive water conservation measures (low-flow plumbing fixtures) which reduce day-to-day water use. There may also be secondary effects, such as the utility revenue losses that are experienced when M&I users reduce consumption during shortages.

## 3.1 CONCEPTUAL APPROACHES TO M&I WATER SUPPLY EVALUATION

The alternative regulation schedules could potentially affect the frequency, severity, and duration of M&I water shortages. The conceptual basis for evaluating the economic effects of changes in M&I water supply associated with alternative plans is society's willingness to pay (WTP) for the increase in the value of goods and services attributable to the water supplied. The Corps' planning guidance stipulates that where the price of water reflects its marginal cost, the price should be used to calculate WTP for water supply (in this case, for the amount of water foregone in the supply shortfall). In the absence of such direct measures of WTP, the effects of water supply plans should instead be measured by the least cost alternative (LCA) to replace the shortfall in supply

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The LCA method is widely used in the Corps, given the difficulty of directly measuring WTP for water supply. However, for the LORSS, WTP was selected as the primary approach to estimate M&I water supply impacts for two principal reasons. The first reason concerns how M&I water is supplied to users in the LEC. In the LEC service areas, M&I water is supplied to users by local utilities. The utilities draw upon local water resources (primarily groundwater) to meet their customers' needs. When shortages occur during prolonged dry periods, the utilities can draw upon the regional water supply system to augment their supplies or the utilities can develop supplemental sources of water. These supplemental sources include: (1) developing additional well fields, (2) instituting more aggressive water conservation measures, or (3) tapping the deep Floridan aquifer, treating this brackish water with reverse osmosis and blending it with water from other sources.

The ability of local utilities to draw upon the regional system or tap local resources for alternative sources of supply is not a practical alternative. The LCA for a utility during a particular shortage would depend on the condition of the regional system. If the shortage was localized, a utility might be able to draw freely upon the regional system, and supplemental sources of supply would not be needed. However, if the water shortage was regional in nature, then access to regional water supplies would be limited by widespread shortages and institutional restrictions, limiting the ability of local water utilities to develop alternative sources of supply.

Table 3-1 presents a summary of recommendations prepared by the SFWMD for the Draft Lower East Coast Water Supply Master Plan (1997). These recommendations illustrate the type of water supply measures that are considered to augment regional and local water supplies. The SFWMD has prepared preliminary cost estimates for some of these measures. Since no capacity estimates were prepared, estimates of unit cost are not available. In addition, the scale of the measures and the uncertainty of their costs make LCA-based estimation of M&I water supply effects impractical for the LORSS. Nevertheless, this information provides a context for evaluating the output of the WTP approach.

The second reason that WTP was selected as the principal approach for calculating the economic effects of M&I water shortages is based on ability of the EPP to estimate M&I water supply effects of the alternative regulation schedules. The SFWMM runs conducted for this investigation compared M&I water supply with demand. This requires a disaggregation/distribution procedure that will account for spatial and sectoral uses, as well as groundwater pumpage. In its 36-year simulations, the SFWMM estimated the location, severity, and duration of M&I water supply shortages. It also simulated the frequency and phase of water shortage declarations based on: (1) Lake Okeechobee levels and (2) salinity intrusion into coastal aquifers (estimated using water surface elevations in monitoring wells). These outputs from the SFWMM were then input to the EPP to calculate the economic effects of changes in the level of M&I water supply for each alternative regulation schedule.

For each of the water shortage phases, the EPP estimates dollar damages from cutbacks based on the WTP (in dollars per 1000 gallons) of regional M&I water consumers. The SFWMD developed these public water supply loss values on the basis of a 1992 survey of M&I water users in south Florida. The survey, which was conducted following a regional water shortages in 1989 and 1992, queried respondents' WTP for water under Phase III and Phase IV reductions. SFWMD staff economists adjusted these values to estimate WTP values for Phases I and II and inflated the WTP values for all four water shortage phases to reflect consumer surplus. The water supply shortfalls in a given shortage phase are multiplied by the WTP associated with that phase to determine the economic costs of the shortage. The values of the unmet water demands during M&I shortages are the basis for comparing the alternative regulation schedules against the without-project future conditions.

**TABLE 3-1**
**RECOMMENDATIONS OF THE**
**DRAFT LOWER EAST COAST WATER SUPPLY MASTER PLAN**

| |
|---|
| **Regional:** |
| Water Resource Partnerships/Basin Level Planning |
| Alternative Water Supply Development |
| Regional Storage Recommendation |
| Modifications to SFWMD Regulatory Program: Permit Duration |
| Modifications to SFWMD Regulatory Program: Level of Certainty |
| Saltwater Intrusion Management |
| Floridan Aquifer Regional Model Development |
| Aquifer Storage and Recovery Working Group |
| East Coast Buffer/Water Preserve Areas |
| Lake Okeechobee Regulation Schedule |
| Funding Strategy |
| **Northern Palm Beach County:** |
| North Palm Beach County Water Management Plan |
| L-8 Option |
| Discharges to Lake Worth Lagoon via C-17 |
| **LEC-SA1:** |
| Southeastern Palm Beach County Integrated Water Resource Plan |
| Regional Groundwater Aquifer ASR Pilot Project |
| Southeastern Lake Worth Drainage District Storage Feasibility Analysis |
| Site 1 Reservoir |
| Utility Well Field Expansion |
| **LEC-SA2:** |
| Coastal Broward County Integrated Water Resource Management Plan |
| Broward County Secondary Canals Recharge Network |
| Utility Well Field Expansion |
| **LEC-SA3:** |
| South Dade County Integrated Water Resource Management Plan |
| C-4 Structures |
| Utility Aquifer Storage and Recovery |

## 3.2 EVALUATION OF ALTERNATIVE REGULATION SCHEDULES

The NED costs of reductions in M&I water supply are the changes in the quantity or price of delivered water over time between the with- and without-project conditions. The SFWMM runs indicate that there will be unmet demand for M&I water supply under both existing and future conditions for the current regulation schedule and the alternative regulation schedules. Table 3-2 summarizes the economic value of unmet demand for M&I water supply associated with the current regulation schedule and the five alternative schedules under the 2000 scenario. As was the case with agricultural water supply, the larger the value, the greater the losses/negative effects associated with water shortages. Alternative regulation schedules with values larger than the without project condition will worsen M&I water supply shortages. Alternatives with lower values than the without project condition represent improvements (i.e., reductions in unmet demand).

Average annual costs are included in this table, which were calculated as the arithmetic average over the 36-year simulation period. The values in Table 3-2 represent the simulated dollar amounts that M&I water users are willing to pay for water they want but do not receive during water shortages.

In Summary, as is evident by Table 3-2, all alternatives perform the same and have identical values of unmet demand.

## TABLE 3-2
## VALUE OF UNMET DEMAND FOR M&I WATER SUPPLY (2000)
## ($2005)

| Scenario | Area | Total M&I 2000 | Average Annual M&I 2000 |
|---|---|---|---|
| 2007LORS | SA1 | $59,341,000 | $1,648,361 |
| 2007LORS | SA2 | $153,523,000 | $4,264,528 |
| 2007LORS | SA3 | $108,622,000 | $3,017,278 |
| 2007LORS | SA4 | $9,091,000 | $252,528 |
| 2007LORS | **Total** | $330,557,000 | $9,182,695 |
| 1bs2* | SA1 | $3,811,000 | $105,861 |
| 1bs2* | SA2 | $4,668,000 | $129,667 |
| 1bs2* | SA3 | $6,957,000 | $193,250 |
| 1bs2* | SA4 | $616,000 | $17,111 |
| 1bs2* | **Total** | $16,052,000 | $445,889 |
| 1bs2_m* | SA1 | $3,811,000 | $105,861 |
| 1bs2_m* | SA2 | $4,668,000 | $129,667 |
| 1bs2_m* | SA3 | $6,957,000 | $193,250 |
| 1bs2_m* | SA4 | $616,000 | $17,111 |
| 1bs2_m* | **Total** | $16,052,000 | $445,889 |
| 2a* | SA1 | $3,811,000 | $105,861 |
| 2a* | SA2 | $4,668,000 | $129,667 |
| 2a* | SA3 | $6,957,000 | $193,250 |
| 2a* | SA4 | $616,000 | $17,111 |
| 2a* | **Total** | $16,052,000 | $445,889 |
| 2a_m* | SA1 | $3,811,000 | $105,861 |
| 2a_m* | SA2 | $4,668,000 | $129,667 |
| 2a_m* | SA3 | $6,957,000 | $193,250 |
| 2a_m* | SA4 | $616,000 | $17,111 |
| 2a_m* | **Total** | $16,052,000 | $445,889 |
| 4* | SA1 | $3,811,000 | $105,861 |
| 4* | SA2 | $4,668,000 | $129,667 |
| 4* | SA3 | $6,957,000 | $193,250 |
| 4* | SA4 | $616,000 | $17,111 |
| 4* | **Total** | $16,052,000 | $445,889 |

** Indicates the change in unmet demand from the base (2007LORS) to the alternative*

# 4. COMMERCIAL NAVIGATION

## OVERVIEW

The purpose of this chapter is to evaluate the potential impact of alternative regulation schedules on commercial navigation in the Lake Okeechobee Waterway, which consists of Lake Okeechobee, the Caloosahatchee River, and the St. Lucie Canal. The alternative regulation schedules were designed to have different effects on water levels in Lake Okeechobee. The potential impacts on commercial navigation are based on associated changes in the frequency of low water events from the current plan, 07LORS, to each alternative. If some portion of the commercial vessel fleet draws all of the waterway's authorized depths, reduced lake stages may prohibit passage of those vessels, delay their passage, or induce reductions in their loads. These impacts could have economic impacts on the shippers or the commodities being transported.

As shown in Table 4-1, there are some differences in the frequency of events among the alternative regulation schedules and the 2007 LORS (07LORS) schedule. In the 36-years of record simulations, the model estimated that there would be one additional time that the lake stage is below 12 feet for more than 365 days between the 07LORS without-project condition schedule and each alternative. The number of years that the lake stage is below 11 feet for greater than 100 consecutive days over the 36-year simulation resulted in each of the alternative regulation schedules having more of these low-water years. The number of days that lake stage is below 12.56 feet over the 36-year simulation for each alternative is greater than the 07LORS alternative. The assessment of commercial navigation impacts will be based on the differences between the current regulation schedule (07LORS) and each of the four alternative regulation schedules for the three performance measures shown in Table 4-1. Based on these performance measures, ranking the alternatives from least to worst impact on commercial navigation would be as follows: (1) 07LORS; (2) 1bS2-A; (3) 1bS2-m; (4) 4-A; (5) 2a-B; and (6) 2a-m.

## 4.1 PHYSICAL FEATURES OF THE WATERWAY

The Lake Okeechobee Waterway was completed in 1937 and includes 154 miles of navigation channel and five lock structures linking Stuart on the Atlantic Ocean with Ft. Myers on the Gulf of Mexico. The five lock and dams (from west to east) are: W.P. Franklin, Ortona, and Moore Haven on the Caloosahatchee River; and Port Mayaca and St. Lucie on the St. Lucie Canal. The Moore Haven and Port Mayaca locks connect Lake Okeechobee with the Caloosahatchee River and St. Lucie Canal, respectively. Using the locks to designate waterway reaches, the channel dimensions of the Lake Okeechobee Waterway at lake elevation 12.56 ft. NGVD are presented in Table 4-2. As indicated in this table and Figure 4-1, there are two routes from Port Mayaca on Lake Okeechobee's eastern shore to Clewiston on the southwestern shore. Route 1, which cuts across the lake, has an authorized channel depth of eight feet. However, due to one and a half feet of shoaling in the lake just west of Port Mayaca Lock, at the 12.56 feet lake stage navigation depth is now equivalent to six and a half feet. Route 2, which hugs the eastern shoreline, is known as the rim canal. This route has a shallower authorized channel of six feet and is longer than Route 1, but it is more sheltered. However, due to the one and a half feet of shoaling, at the 12.56 feet lake stage, the navigation depth is now equivalent to four and a half feet. The shallow depths of Lake Okeechobee can induce severe wave conditions on the lake that are disproportionate to wind velocities. During inclement weather, the rim canal is the preferred route between Clewiston and Port Mayaca.

**TABLE 4-1**
**COMMERCIAL NAVIGATION**
**SIMULATED NUMBER OF UNDESIRABLE LOW LAKE STAGE EVENTS**

| | 07LORS | Alt 1bS2-A | Alt 1bS2-m | Alt 4-A | Alt 2a-B | Alt 2a-m |
|---|---|---|---|---|---|---|
| Number of times lake stage below 12 feet for more than 365 days | 1 | 2 | 2 | 2 | 2 | 2 |
| Number of year lake stage below 11 feet over 100 days | 3 | 7 | 7 | 8 | 9 | 9 |
| Number of days lake stage < 12.56’ | 2577 | 4809 | 4842 | 4841 | 5141 | 5776 |
| % Increase in number of days over 36 Years | | 16.9% | 17.2% | 17.2% | 19.5% | 24.3% |

**TABLE 4-2**
**CHANNEL DIMENSIONS LAKE OKEECHOBEE WATERWAY**

| Waterway Reach | Channel Dimensions | Length of Reach |
|---|---|---|
| Atlantic Intracoastal to St. Lucie Lock | outside project limits | 15.1 miles |
| St. Lucie Lock to Port Mayaca Lock | 8’ x 100’ | 23.7 miles |
| Port Mayaca Lock to Clewiston (rim canal) | 6’ x 100’ | 39.5 miles |
| Port Mayaca Lock to Clewiston (open lake) | 8’ x 100’ | 28.5 miles |
| Clewiston to Moore Haven Lock (rim canal) | 8’ x 80’ | 10.5 miles |
| Moore Haven Lock to Ortona Lock | 8’ x 90’ | 15.5 miles |
| Ortona Lock to W.P. Franklin Lock | 8’ x 90’ | 27.9 miles |
| W.P. Franklin to Gulf Intracoastal | outside project limits | 33.2 miles |
| | TOTAL | 154.4 miles (open lake)<br>165.4 miles (rim canal) |

The depth of this waterway is controlled by managing lake levels; no maintenance dredging is conducted for this waterway. Consequently, lake levels above (or below) 12.56 ft. NGVD will result in a corresponding increase (or decrease) in channel depths. Navigation depths are computed by subtracting 12.56 feet from the lake elevation and then adding six and a half feet for Route 1 and four and a half feet for Route 2. For example, at a lake level of 11 ft. NGVD the channel depth would be 4.94 ft. NGVD (11.00-12.56+6.50) in the open lake and 2.94 ft. NGVD (11.00-12.56+4.50) in the rim canal.

There are five locks on the Lake Okeechobee Waterway, all operated by the Corps. Three locks are located on the Caloosahatchee River: the Moore Haven Lock on Lake Okeechobee (R.M. 78), the W.P. Franklin Lock and Dam (R.M. 122) between Tice and La Belle, and the Ortona Lock (R.M. 93.6). In addition, there are two locks on the St. Lucie Canal: the Port Mayaca Lock on the lake's eastern shore (R.M. 38.5) and the St. Lucie Lock (R.M. 15.3) near Interstate 95 (I-95).

Table 4-3 presents the lock dimensions for the five locks and dams on the Lake Okeechobee Waterway. The elevation of the bottom of Lake Okeechobee is approximately equal to sea level. As a result, with a lake elevation at 15.5 ft. NGVD, the Caloosahatchee and St. Lucie locks would have a combined lift of approximately 15.5 feet and 14.5 feet, respectively. The difference is explained by the Caloosahatchee locks releasing further inland (upstream) from the coast than the St. Lucie locks. Three of the locks have head differences of several feet. However, two locks have significantly larger head differences. Ortona Lock has a head difference of approximately eight feet, and St. Lucie typically has lift elevations in excess of 13 feet. The chamber depths of the five locks depend on the lock head. At the lowest operational levels, the chambers would have depths far in excess of the authorized project depths. Therefore, the lock chambers do not constitute depth constraints to waterway traffic under conceivable circumstances.

**TABLE 4-3**
**LOCK DIMENSIONS**
**LAKE OKEECHOBEE WATERWAY**

| Lock | Dimensions (feet) |
|---|---|
| St. Lucie | 50' x 250' |
| Port Mayaca | 56' x 400' |
| Moore Haven | 50' x 250' |
| Ortona | 50' x 250' |
| W.P. Franklin | 56' x 400' |

## 4.2 WATERWAY OPERATION

As previously discussed, the Caloosahatchee River and the St. Lucie Canal are primary outlets for Lake Okeechobee and critical components of the Lake Okeechobee Waterway. The locks and dams are operated in a manner that supports commercial navigation as well as other project objectives. Each of the locks and dams has a spillway that can be used for the lake's regulatory releases. The spillways and the locks release freshwater downstream and eventually into the Gulf of Mexico and the Atlantic Ocean. Releases are carefully controlled to regulate lake levels, maintain adequate depths for navigation in the two outlet waterways, and minimize salinity impacts on the two receiving estuaries.

Water is typically released through the Caloosahatchee River before the St. Lucie Canal for two reasons. First, freshwater releases to the St. Lucie Canal are limited due to ecological effects of freshwater releases on the estuary. Second, the water treatment facility for the town of Olga is located in the Caloosahatchee reach between the W.P. Franklin and Ortona locks. The plant is not allowed to discharge chloride-treated effluent to the river if chloride concentrations in the receiving waters are in excess of 250 parts per million (ppm). The three Caloosahatchee locks and dams are typically operated to keep salinity in this river reach low enough to receive the plant effluent. Since the Caloosahatchee River downstream of W.P. Franklin is tidal, this involves a continual release of freshwater from Lake Okeechobee. In addition, the lock operators will occasionally flush the waterway to remove algae and to restore dissolved oxygen levels. In the St. Lucie Canal, the St. Lucie Lock is the main interface between Lake Okeechobee and the Atlantic Ocean. When the lake level is below 14 ft. NGVD, the Port Mayaca Lock is opened, and water levels for the reach from Lake Okeechobee to the St. Lucie lock are controlled by lake levels.

During water shortages, the operation of the Lake Okeechobee Waterway is altered. In all four phases of the SFWMD’s Water Shortage Plan, lock operations can be restricted to conserve water in Lake Okeechobee and maintain acceptable salinity concentrations in the estuaries downstream of the locks. The operation of the W.P. Franklin Lock is a particular focus of the plan. Under the Plan, the SFWMD will request the Corps to limit lockages at W.P. Franklin to once every four hours once a week if chloride concentrations at the lock exceed 180 ppm and a rainfall event in excess of one inch in 24 hours is not predicted in the surface water use basin within the next 48 hours. If these restrictions are insufficient to reach the salinity target at W.P. Franklin, the SFWMD can then request the Corps to restrict lockages to once every four hours, twice per week. If these additional measures are insufficient, the SFWMD can request that the Corps prohibit lockages.

## 4.3 COMMERCIAL WATERWAY USE

Table 4-4 provides a summary of the net short tons of freight traffic traversing the Lake Okeechobee Waterway from 1986 through 2004. Commercial navigation on this waterway was relatively stable from 1987 through 2000 with substantial variability year to year. However, there has been a serious decline in freight traffic (net short tons) since 2001. As shown in Table 4-4, the Lake Okeechobee Waterway was used to transport 728,000 net short tons with 2,445 trips in 2000 and only 384,000 net short tons with 2,157 trips in 2001. In 2001, commercial net short tons dropped by 47 percent, but the number of commercial trips only decreased by 12 percent. At the same time, there was a dramatic decrease in the total number of vessels going through the locks from 2000 (52,174) to 2001 (25,036) (these numbers include recreation vessels). From 2001 to 2002, the number of trips as well as the net short tons dropped drastically from 2,157 to 254 trips and 384,000 to 36,446 net short tons. These low numbers continued through 2004 with 142 trips and 332 net short tons of freight. The Jacksonville Lock and Dam Supervisor, Mark Abshire, estimates that over 99 percent of the commercial traffic only uses either W.P. Franklin Lock or St. Lucie Lock or traverse the waterway without using any locks. Therefore, when lock restrictions occurred during the drought of record in 2001, the delays did not deter the commercial activity whereas recreational navigation and the estimated less than one percent of commercial traffic, like commercial yacht delivery vessels and commercial fishing boats, that cross Lake Okeechobee and use more than one lock were negatively impacted.

**TABLE 4-4**
**FREIGHT TRAFFIC, 1986-2004**
**Lake Okeechobee Waterway**

| Year | Net Short Tons |
|---|---|
| 1986 | 1,320,000 |
| 1987 | 676,000 |
| 1988 | 696,000 |
| 1989 | 680,000 |
| 1990 | 665,000 |
| 1991 | 718,000 |
| 1992 | 753,000 |
| 1993 | 832,000 |
| 1994 | 662,000 |
| 1995 | 430,000 |
| 1996 | 409,000 |
| 1997 | 560,000 |
| 1998 | 893,000 |
| 1999 | 850,000 |
| 2000 | 728,000 |
| 2001 | 384,000 |
| 2002 | 36,000 |
| 2003 | 12,000 |
| 2004 | 332 |

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 2006.

Table 4-5, which contains statistics from Waterborne Commerce of the United States, indicates that petroleum products comprised the overwhelming majority of tonnage shipped in years past. Petroleum products included distillate fuel oil, residual fuel oil, and liquid natural gas. Fuel oil shipments averaged approximately 600,000 tons from 1987-2000 peaking in 1998 at 847,000 tons. All shipments were delivered to the Fort Myers oil-fired electrical generating plant. On an annual basis, fuel oil deliveries from Charlotte Harbor, Florida to Florida Power and Light Company's plant at Fort Myers have accounted for 88 to 99 percent of all commercial waterborne commerce from 1987-2000. These shipments did not pass through any of the Corps locks on the Okeechobee Waterway. Florida Power and Light Company's Fort Myers power plant completed a re-powering in 2002. Re-powering at this plant involves the conversion from oil-fired boiler technology to natural gas-fired, combined-cycle technology. Pipelines of the Florida Gas Transmission Company supply the natural gas. As a result, in 2004, there were no petroleum products transported on the Caloosahatchee. This explains the majority of the drastic decline in net short tons from 2001 to 2002 through 2004.

**TABLE 4-5**
**FREIGHT TRAFFIC, 2000-2004**
**Lake Okeechobee Waterway**
**Total Trips and Net Short Tons by Commodity**

| Commodity | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|
| Total Trips | 2,445 | 2,157 | 254 | 221 | 142 |
| All Commodities | 728,000 | 384,000 | 36,446 | 12,451 | 332 |
| Petroleum Products | 706,000 | 379,000 | 32,780 | 12,423 | 0 |
| Primary Manufactured Goods | 14,000 | 2,000 | 2,990 | 0 | 300 |
| Crude Materials | 2,000 | 1,000 | 0 | 0 | 0 |
| Manufactured Equipment, Machinery & Products | 5,000 | 2,000 | 676 | 28 | 32 |
| Ton-Miles (000's) | 16,197 | 9,703 | 3,272 | 501 | 46 |

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 2004.

The lock operators maintain records of the lock operations, including the general characteristics of vessels passing through the locks. These data are compiled in a national database, the Lock Performance Monitoring System (LPMS). This database is maintained by the Navigation Data Center at the Corps of Engineers Water Resources Support Center in Washington. D.C.

Data from the LPMS includes characteristics of the commerce vessels used on the waterway. Table 4-6 summarizes the LPMS vessel profiles for the Lake Okeechobee Waterway locks for 2001. The lock data contains information about recreational boats passing through the locks, as well as commercial traffic.

The number of commercial vessels passing through the locks in 2001 range from 31 to 219 for Ortona and the St. Lucie locks, respectively. The average number of barges per tow is small, ranging from 1.0 to 2.2 for St. Lucie and Moore Haven locks, respectively. The relatively light volume of traffic and the small tow sizes explain the minimal delays at the waterway locks.

Additional data on the commercial vessels using the Lake Okeechobee Waterway is provided in Table 4-7, which presents Florida state vessel registrations for the counties surrounding Lake Okeechobee. This table includes commercial and recreational vessels by length class. The vessels in this table are primarily small, recreational craft. However, there are larger commercial vessels as well. There is a small but viable fleet of day/dinner cruise vessels that operate during the tourist season from Pahokee, on the eastern shore of Lake Okeechobee, and from Ft. Myers. These vessels have relatively shallow drafts, in the range of four to five feet. The smaller commercial craft may be

**TABLE 4-6**
**VESSEL PROFILES**
**LAKE OKEECHOBEE WATERWAY LOCKAGES**
**January – December 2001**

| | Vessels | | | | Barges | | | Total | Tons (000) |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Recreation | Tows | Other | Total | Loaded | Empty | | |
| **St. Lucie** | | | | | | | | | |
| Upbound | 2387 | 2265 | 107 | 15 | 108 | 59 | 49 | 2495 | 7 |
| Downbound | 1904 | 1780 | 112 | 12 | 114 | 82 | 32 | 2018 | 13 |
| Total | 4291 | 4045 | 219 | 27 | 222 | 141 | 81 | 4513 | 20 |
| **Port Mayaca** | | | | | | | | | |
| Upbound | 2857 | 2816 | 17 | 24 | 23 | 13 | 10 | 2880 | 2 |
| Downbound | 2348 | 2314 | 17 | 17 | 20 | 12 | 8 | 2368 | 2 |
| Total | 5205 | 5130 | 34 | 41 | 43 | 25 | 18 | 5248 | 4 |
| **Moore Haven** | | | | | | | | | |
| Upbound | 2270 | 2216 | 19 | 35 | 42 | 32 | 10 | 2312 | 3 |
| Downbound | 2669 | 2618 | 19 | 32 | 40 | 34 | 6 | 2709 | 4 |
| Total | 4939 | 4834 | 38 | 67 | 82 | 66 | 16 | 5021 | 7 |
| **Ortona** | | | | | | | | | |
| Upbound | 1877 | 1848 | 12 | 17 | 20 | 17 | 3 | 1897 | 2 |
| Downbound | 2288 | 2251 | 19 | 18 | 23 | 18 | 5 | 2311 | 3 |
| Total | 4165 | 4099 | 31 | 35 | 43 | 35 | 8 | 4208 | 5 |
| **W.P. Franklin** | | | | | | | | | |
| Upbound | 3014 | 2993 | 17 | 4 | 21 | 11 | 10 | 3035 | 1 |
| Downbound | 3424 | 3398 | 17 | 9 | 22 | 16 | 6 | 3446 | 2 |
| Total | 6438 | 6391 | 34 | 13 | 43 | 27 | 16 | 6481 | 4 |
| | | | | | | | | | |
| Total | 25,038 | 24,499 | 356 | 183 | 433 | 294 | 139 | 25,471 | |

Source: U.S. Army Corps of Engineers, Lock Performance Monitoring System, 2001.

fishing boats associated with marinas or fish camps on Lake Okeechobee. These operations rent fishing boats and offer guide services as well. The vessel registration information in Table 4-7 must be interpreted with caution for two reasons. First, Palm Beach and Martin Counties are coastal counties with potential vessel registrations for the Lake Okeechobee Waterway and the Atlantic Ocean. Second, the county of registration may not necessarily be the same as the county of operation.

**TABLE 4-7**
**VESSEL REGISTRATIONS**
**LAKE OKEECHOBEE COUNTIES**
**2005**

| Class | Length | Type | Glades | Hendry | Martin | Okeechobee | Palm Beach | Total |
|---|---|---|---|---|---|---|---|---|
| Class A-1 | <12' | Pleasure | 106 | 445 | 2,223 | 430 | 8,752 | 11,569 |
| | | Commercial | 6 | 6 | 11 | 11 | 76 | 110 |
| Class A-2 | 12'-15'11' | Pleasure | 389 | 752 | 2,277 | 1,433 | 6,009 | 10,860 |
| | | Commercial | 31 | 26 | 67 | 73 | 169 | 366 |
| Class 1 | 16'-25'11' | Pleasure | 903 | 1,475 | 9,126 | 3,853 | 21,660 | 37,017 |
| | | Commercial | 35 | 72 | 297 | 96 | 514 | 1,014 |
| Class 2 | 26'-39'11" | Pleasure | 30 | 267 | 2,547 | 119 | 5,962 | 8,925 |
| | | Commercial | 1 | 22 | 109 | 6 | 213 | 351 |
| Class 3 | 40'-64'11" | Pleasure | 16 | 78 | 457 | 9 | 1,128 | 1,688 |
| | | Commercial | 0 | 4 | 43 | 0 | 80 | 127 |
| Class 4 | 65'-109'11" | Pleasure | 0 | 0 | 28 | 1 | 102 | 131 |
| | | Commercial | 0 | 0 | 5 | 0 | 15 | 20 |
| Class 5 | >110' | Pleasure | 0 | 0 | 1 | 0 | 5 | 6 |
| | | Commercial | 0 | 0 | 0 | 0 | 0 | 0 |
| Canoes | | Pleasure | 10 | 19 | 96 | 18 | 245 | 388 |
| | | Commercial | 0 | 0 | 0 | 0 | 2 | 2 |
| | Sub-total | Pleasure | 1,438 | 3,036 | 16,755 | 5,863 | 43,863 | 70,971 |
| | Sub-total | Commercial | 73 | 130 | 532 | 186 | 1,069 | 1,990 |
| | | **TOTAL** | 1,511 | 3,166 | 17,287 | 6,049 | 44,932 | 72,961 |

Source: Bureau of Vessel Titles and Registrations, Florida Department of Highway Safety and Motor Vehicle. 2005.

## 4.4 EVALUATION OF ALTERNATIVE REGULATION SCHEDULES

The economic effects on commercial navigation are the changes in the value of resources required to transport commodities and the increase in the value of output from these goods and services. Changes in transportation costs may stem from changes in: (1) the vessel fleet used on the waterways, (2) efficiency in the use of existing vessels, (3) transit time, (4) origin-destination patterns, (5) cargo handling, (6) tug assistance, and (7) use of waterborne transportation, rather than competing modes. The NED effects include the costs of resources, impacts on net income, and operating costs.

The statistics on waterborne commerce and vessels on the Lake Okeechobee Waterway were complemented by extensive field research in the December 1998 LORSS economic evaluation. This research included interviews with: (1) lockmasters of each lock, (2) waterway users, (3) waterway interest groups, and (4) Corps operations personnel involved with the Lake Okeechobee Waterway project. These interviews solicited opinions regarding the potential navigation impacts from changes in the LORS. In addition, the waterway was traversed as part of this field research to identify the sensitivity of commercial navigation to changes in lake levels. This included taking spot soundings to assess channel conditions and evaluating aids to navigation. Follow-up telephone conversations were conducted for this economic evaluation. The findings are highlighted below.

### 4.4.1 Commercial Traffic

Based on information from the lockmasters, there are no commercial shipping lines that regularly pass through the Lake Okeechobee waterway. As a result, there is no fleet of regular commercial waterway users, and there is no regular routing of commodity shipments through the waterway. The commercial traffic consists of special barge shipments that are taking advantage of the shortcut across the peninsula, which can save three and one half days of travel. In some cases, deep-draft tugs transfer the tows to shallow-draft tugs for passage through the Lake Okeechobee Waterway.

In the absence of an established fleet of vessels using the waterway, the analysis of commercial navigation must depend on records of the ad hoc shipments collected as part of the waterborne commerce statistics and the LPMS. It was beyond the scope of this investigation to collect primary data by identifying and interviewing shippers who may use this waterway regarding waterway navigation and their decision-making regarding vessels and origin-destination patterns.

The absence of regular vessel traffic through the Lake Okeechobee Waterway combined with the historic profiles of commodities and vessels suggest that commercial navigation on this waterway is and will be at a minimum. With the absence of regular vessel traffic, data is not available to estimate how the fleet of commercial vessels using the waterway might change with the modification of the lake regulation schedule relative to the existing schedule. However, very little change, if any, would be expected, since the differences between the stage-duration curves of the existing condition and new alternatives are relatively small and there is no dedicated fleet.

### 4.4.2 Groundings

Interviews held with the lockmasters and Corps operations personnel suggested that when lake levels are below 12 ft. NGVD, the frequency of vessel groundings increases. While the problem is most severe for recreational vessels, commercial traffic is subject to groundings, as well. In general, groundings occur when vessels do not stay in the channel. Since most commercial vessels will endeavor to remain in the channel, groundings are less of a problem for commercial vessels than recreational craft. However, at very low lake levels, the authorized channel depths cannot be maintained. Under these circumstances, the Coast Guard will install temporary markers to keep vessels in deep water within the channels. The Coast Guard will also issue a Notice to Mariners warning commercial and recreational navigators about the reduced channel depths.

Of particular concern are two shoal areas that pose hazards to vessels that have drafts close to the authorized channel depth. During average and high lake levels these shoals are not a threat to commercial navigation, but during low lake stages shoals can be problematic. In particular, there is a rock shelf on Route 2 near Port Mayaca lock and Rocky Reef on Route 1 near Clewiston that are hazardous. At Port Mayaca, the shoal allegedly has only six and one half feet of water at lake level 12.56 ft. NGVD, and the Clewiston entrance allegedly has four and one half feet of water at the same lake level.

As lake levels decline, there is less margin for error. Commercial vessels that stray outside of the channel for any reason can run aground. Rocky Reef on Route 1 near Clewiston is particularly unforgiving of errors. Much of Lake Okeechobee's bottom is soft, but running aground at this location could cause severe damage to vessels. For commercial traffic, it can be particularly challenging to stay in the smaller channel during low lake levels due to the wave and wind action for which Lake Okeechobee is famous. The lower lake levels compound problems with waves since the shallower depths exacerbate wave formation.

If vessels run aground, the Coast Guard at Ft. Pierce is contacted, and a tow from Ft. Meyers is requested. If there is danger to life or property, the Corps project operations office in Clewiston, on the southwestern edge of Lake Okeechobee, will provide assistance. The Corps keeps records of such assistance, but only for two years. As a result, information about groundings on Lake Okeechobee is primarily anecdotal.

### 4.4.3 Aids To Navigation

Based upon a detailed inspection of the Lake Okeechobee Waterway, it appears there are some problems with aids to navigation that pose hazards to commercial and recreation vessels. Route 1 across Lake Okeechobee is particularly problematic in this regard. Specifically, the channel markers appear to be spaced too far apart for safe navigation. In particular, offshore from Clewiston, Route 1 turns sharply northward to pass through Rocky Reef at the "Hole in the Wall." There are three buoys that mark the channel through this turn: one for the approach, one for the pivot point, and one for exit. The problem is that inexperienced mariners might be tempted to cut across the hypotenuse of what is almost a right triangle, moving directly from the approach to the exit buoy. Unfortunately, this would be a path directly over the reef. This path might not be problematic during average or high lake levels, but at low lake levels groundings would result.

In addition, waterway users indicate that in many locations the waterway buoys exceed the channel dimensions significantly. Again, during average or high water, this may not be a problem, but during low lake levels, shallow water could be encountered, as evidenced by the Coast Guard's placement of temporary markers.
Finally, on Route 1, the channel marker buoys seem to be spaced too far apart. While compass headings for this route are provided in navigational charts for Lake Okeechobee, visual cues (i.e., confirmation) using the channel markers are not possible at some points along this route, particularly offshore of Port Mayaca.

### 4.4.4 Lockage Restrictions During Water Shortages

Although the restriction of lockages as a result of water shortages is uncommon, they may cause delays to some commercial and recreational waterway traffic. Delays are offset to some degree by the opening of the Port Mayaca lock during low lake levels. However, there are economic effects associated with these delays, particularly for some commercial traffic.

## 4.5 ASSESSMENT

Based upon hydrologic performance measures, field research and database searches regarding commercial navigation on the Lake Okeechobee Waterway, it can be concluded that the effects of each alternative regulation schedule would have a minor negative impact on commercial navigation relative to the current schedule. The commercial navigation issues on this waterway are directly or indirectly related to lake levels. The infrequent and irregular nature of navigation on the waterway raises the question of whether some shipments through the waterway could be deferred until lake levels increase, with little ill effect. In addition, those shippers who use this waterway may already have made adjustments to meet the fluctuations in lake levels.

However, those that depend on the waterway and cannot defer until lake levels increase, and lightening their loads is not an option, but can only adjust by going around the peninsula, will increase their travel cost by an estimated $27,850 per trip. Travel time using the waterway takes one and one-half days while travel time around the peninsula requires five days.

Fiscal year (FY) 2006 estimated daily operating costs for shallow-draft tugs range from: $3,000 per day for the 600 horsepower (hp); $5,000 per day for the 800 hp; up to $7,000 per day for the 1,200 hp model. A shallow-draft tug (800 hp) would move the tows in the waterway, and a seagoing tug would move the tows around the peninsula.

An assumption is made that 1,200 hp boats would be required for the outside run and half of the barges used will be covered and the other half would be deck barges. The average cost per barge is $100 per day.

Using the above information, the additional costs incurred for a shipper to detour around the peninsula rather than use the waterway would be $27,850 per trip. This represents the difference between $7,500 to use the waterway (1.5 days * $5,000 for 800 HP Tow) and $35,350 to go around the peninsula (5 days * $7,000 per day + $350 additional barge cost).

In order to estimate the additional increase in commercial navigation costs at different lake stages, information about the number of trips that absolutely must go around the peninsula instead of the waterway must be known. This information is not readily available. Therefore, the magnitude of the negative impact is unknown for each alternative relative to 07LORS. However, given that there is no dedicated fleet, that there is a relatively small difference in the stage-duration curve between the existing operating condition and each proposed alternative, and that there has been a very small amount of commercial traffic since 2001, it is concluded that there will be only minor adverse impacts on commercial navigation.

Therefore, the alternatives are ranked based on the number of times that lake stage is below 12 feet for more than 365 days, the number of years over the 36 years of record that lake stage is below 11 feet for greater than 100 days, and the number of days that the lake stage is below 12.56 feet. The ranking from best to worst alternative is as follows: 07LORS; alternative 1bS2-A; alternative 1bS2-m; alternative 2a-B; alternative 4-A; and alternative 2a-m.

# 5. RECREATION

## OVERVIEW

In this chapter, the potential economic effects of the alternative regulation schedules on recreation are examined. The discussions focus on water-based recreation, specifically recreational boating and sportfishing.

This assessment of recreation impacts of the LORSS alternatives will be limited to recreational activities that occur on Lake Okeechobee and its immediately adjacent waterways and associated landside facilities.

The economic effects of the alternative regulation schedules on recreation are estimated by quantifying the differences in the quantity and quality of recreation activities expected to occur under with- and without-project conditions. Estimating the change in economic value of recreational activities can be approached in three steps: (1) identifying the recreational resources of Lake Okeechobee and its associated waterways, (2) evaluating the quality and quantity of recreation activities under the with- and without-project conditions, and (3) comparing these quantities and qualities to estimate the effects of the alternative regulation schedules.

## 5.1 RECREATION RESOURCES

Lake Okeechobee is the largest recreational resource in the region. Lake Okeechobee and its associated waterways and shoreline provide a wide variety of water-based recreation activities for local residents and out-of-state visitors, including: fishing, boating, picnicking, sightseeing, camping, swimming, hunting, air boating, and hiking. The western side of Lake Okeechobee is relatively shallow, with an extensive littoral zone, which comprises approximately one-quarter of the lake area. The littoral zone provides critical habitat for the lake's popular sport fishery and attracts thousands of waterfowl, which lure hunters during the fall migration.

Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. The recreational fishery includes individual anglers fishing from boats and the shore, as well as guided sportfishing. The fishery is large and productive due to the extensive littoral zone that provides abundant habitat for juvenile and adult fish.

Profiles of the main recreation sites on the Lake Okeechobee Waterway are presented in Table 5-1. As indicated in this table, there are 39 recreational sites on the waterway and 34 boat-launching sites that provide access to Lake Okeechobee. The ramps were of particular interest in the investigation since ramp access to the lake could be affected by fluctuations in lake levels that result from the implementation of the alternative regulation schedules.

## TABLE 5-1
## RECREATIONAL FACILITIES, LAKE OKEECHOBEE WATERWAY

| | Corps Operated | Campsites | Showers | Drinking Water | Sanitary | Day Use | Launch Ramp | Marina | Boat-In Camping | Fishing Pier |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. W.P. Franklin Lock and Dam (North) | • | • | • | • | • | | • | | • | • |
| 2. W.P. Franklin Lock and Dam (South) | • | | • | • | | • | • | | | |
| 3. Alva Access Area | • | | | | | | • | | | |
| 4. La Belle Lions Park | | | | | | • | | | | |
| 5. La Belle Access Area | | | | | | • | • | | | |
| 6. Barron Park | | | | • | | • | | | | |
| 7. Belle Hatchee Marina | | | • | • | | | • | • | | |
| 8. Port La Belle Marina | | | • | • | | | • | • | | |
| 9. Ortona Lock and Dam (North) | • | | | • | | • | • | | | • |
| 10. Ortona Lock and Dam (South) | • | • | • | • | • | • | | | | • |
| 11. Moore Haven Lock (East) | • | | | | | | | | | • |
| 12. Moore Haven Recreational Village | | • | • | • | • | • | • | • | | |
| 13. Sportsman's Village | | | | | | • | • | | | |
| 14. Fisheating Creek | | | | | | | • | | | |
| 15. Harney Pond Canal | | | | • | | • | • | | | • |
| 16. Bare Beach | | | | | | • | • | | | |
| 17. Indian Prarie Canal | | | | | | | • | | | • |
| 18. Okee-Tanti | | • | • | • | • | • | • | • | | |
| 19. C.Scott Driver | | | | | | | • | | | |
| 20. Okeechobee | | | | • | | • | • | | | • |
| 21. Taylor Creek | | | | | | | • | | | |
| 22. Nubbin Slough | | | | | | | • | | | |
| 23. Henry Creek | | | | | | | • | | | |
| 24. Chancy Bay | | | | | | | • | | | |
| 25. Port Mayaca Lock and Dam | • | | | | | • | • | | | |
| 26. Canal Point | | | | | | • | • | | | |
| 27. Pahokee | | • | • | • | • | • | • | • | | • |
| 28. Paul Rardin Park | | | | • | | • | • | | | |
| 29. Belle Glade | | • | • | • | • | • | • | • | | • |
| 30. South Bay | | | | | | • | • | | | |
| 31. John Stretch Park | | | | • | • | • | • | | | |
| 32. Corps South Florida Operations | • | | | | | | • | | | |
| 33. Clewiston Park | | | | | | • | • | | | • |
| 34. Liberty Point | | • | • | • | | | • | | | |
| 35. Alvin Ward | | | | • | | • | • | | | |
| 36. Port Mayaca Wayside Park | | | | | | • | | | | |
| 37. Indiantown Marina | | • | • | • | | • | • | • | | • |
| 38. St. Lucie Lock and Dam | • | • | • | • | • | • | • | | • | • |
| 39. Phipps Martin County Park | | • | • | • | • | • | • | | | |

Source: U.S. Army Corps of Engineers. Lake Okeechobee Waterway Recreation Map.

## 5.2 RECREATION RESOURCE USAGE

Estimates of current usage of Lake Okeechobee's recreation resources are contained in the Operation and Maintenance Business Information Link (OMBIL), a database that contains usage data for all Corps recreation projects. Table 5-2 presents the OMBIL data for FY 2002 to FY 2005. This table contains visitor hours and visits.

**TABLE 5-2**
**OMBIL DATA**
**LAKE OKEECHOBEE WATERWAY**
**FY 2002 – FY2005**

| | FY 02 | FY 03 | FY 04 | FY 05 |
|---|---|---|---|---|
| Visitor Hours | 10,181,403 | 11,647,421 | 10,177,780 | 12,086,174 |
| Visits | 1,031,204 | 1,089,528 | 1,026,837 | 1,104,087 |

Source: U.S. Army Corps of Engineers. OMBIL.

## 5.3 FUTURE RECREATION DEMAND

Estimates of future recreation demand were found in the Statewide Comprehensive Outdoor Recreation Plan (SCORP): Outdoor Recreation in Florida-2000. The SCORP divides Florida into recreation regions. Region 10, Treasure Coast, includes Lake Okeechobee. The SCORP categories that apply to recreation on the Lake Okeechobee Waterway are: freshwater boat ramp use, freshwater fishing (non-boat), hunting, and nature study. The 2000, 2005 and 2010 estimates for recreation demand (in user occasions) for these categories are presented in Table 5-3. Freshwater fishing was the only activity that showed a shortage in recreational capacity.

**TABLE 5-3**
**ESTIMATED RECREATION DEMANDS (IN USER OCCASIONS)**
**2000 thru 2010**

| | 2000 | 2005 | 2010 | % Change (2005-2010) |
|---|---|---|---|---|
| Boat Ramp | 673,510 | 750,415 | 826,777 | 9.7% |
| Fishing (non-boat) | 1,370,307 | 1,525,279 | 1,678,705 | 9.6% |
| Hunting | 7,375 | 8,095 | 8,774 | 8.0% |
| Nature Study | 877,187 | 969,527 | 1,058,861 | 8.8% |

Source: Florida Statewide Comprehensive Outdoor Recreation Plan. 2000.

## 5.4 ESTIMATED VALUE OF RECREATION RESOURCES

The information presented previously on the type, quality, and quantity of recreation resources at Lake Okeechobee can be used to estimate the value of the recreational resource. As specified in Corps guidance (ER 1105-2-100), the value of a project's recreation resources should be measured in terms of WTP. The following methodologies can be used to estimate WTP: the travel cost method (TCM), the contingent valuation method (CVM), and the unit day value (UDV) method. Either the CVM or TCM approaches are typically required for projects, like Lake Okeechobee, that exceed 750,000 visitor days per year. This analysis of economic effects is being conducted to provide information to assist project decision-making, but a benefit cost analysis is not required. Therefore, the UDV method was selected as the means to estimate the value of recreation resources at Lake Okeechobee, since the more extensive analyses required by the travel cost and the contingent valuation methods are not needed to support project justification. The UDV method relies on informed judgment to estimate the average WTP for recreation experiences of various types and qualities.

The UDV evaluation procedure requires that the analyst select a specific point estimate from within a range agreed upon by Federal water resource agencies to reflect the quality of the recreational experience along the following dimensions:

- Quality and availability of multiple recreation experiences
- Relative scarcity of the specific recreational experience within the region
- Adequate carrying capacity, without deterioration of the resource or experience
- Easy access to the recreation site(s)
- Aesthetic quality of the environment.

The points assigned to each dimension are then summed to yield a total quality estimate for the project site under both with- and without-project conditions (maximum score = 100). The total quality points are then correlated to a specific dollar value that is intended to approximate an individual's WTP for a day of recreation experience. The conversion factor from points to dollar value is specified in an Economic Guidance Memorandum published annually by the Corps. The individual valuation of the recreation experience is then multiplied by demand to estimate total recreation value. Value ranges and factors used in evaluating recreation characteristics (provided in ER 1105-2-100) are shown in Table 5-4.

Points for each of the five categories were assigned to general recreation and hunting/fishing based on the documents, data, and field work described above. The point assignments are presented in Table 5-5.

## TABLE 5-4
## GUIDELINES FOR ASSIGNING POINTS FOR RECREATION FACILITIES

| Criteria | Judgement Factors | | | | |
|---|---|---|---|---|---|
| Recreation experience | Two general activities | Several general activities | Several general activities; one high quality value activity | Several general activities; more than one high quality value activity | Number of high quality value activities; some general activities |
| Total Points: 30<br>Point Value: | 0-4 | 5-10 | 11-16 | 17-23 | 24-30 |
| Availability of opportunity | Several within 1 hour travel time; a few within 30 minutes travel time | Several within 1 hour travel time; none within 30 minutes travel time | One or two within 1 hour travel time; none within 45 minutes travel time | None within 1 hour travel time | None within 2 hours travel time |
| Total Points: 18<br>Point Value: | 0-3 | 4-6 | 7-10 | 11-14 | 15-18 |
| Carrying capacity | Minimum facility for development of public health and safety | Basic facility to conduct activities | Adequate facilities to conduct without deterioration of the resource or activity experience | Optimum facilities to conduct activity at site potential | Ultimate facilities to achieve intent of selected alternative |
| Total Points: 14<br>Point Value: | 0-2 | 3-5 | 6-8 | 9-11 | 12-14 |
| Accessibility | Limited access by any means to site or within site | Fair access, poor quality roads to site; limited access within site | Fair access, fair road to site; fair access; good roads within site | Good access, good roads to site; fair access, good roads within site | Good access, high standard road to site; good access within site |
| Total Points: 18<br>Point Value: | 0-3 | 4-6 | 7-10 | 11-14 | 15-18 |
| Environmental | Low esthetic factors that significantly lower quality | Average esthetic quality; factors exist that lower quality to minor degree | Above average esthetic quality; any limiting factors can be reasonably rectified | High esthetic quality; no factors exist that lower quality | Outstanding esthetic quality; no factors exist that lower quality |
| Total Points: 20<br>Point Value: | 0-2 | 3-6 | 7-10 | 11-15 | 16-20 |

## TABLE 5-5
## UDV POINT ASSIGNMENTS
## LAKE OKEECHOBEE RECREATION RESOURCES

| | Recreation | Availability | Carrying Capacity | Accessibility | Environmental | Total Points | UDV |
|---|---|---|---|---|---|---|---|
| **Possible Points** | 30 | 18 | 14 | 18 | 20 | 100 | |
| **Assigned Pts** | | | | | | | |
| Hunting & Fishing | 25 | 14 | 11 | 12 | 16 | 78 | $8.41 |
| General Recreation | 15 | 10 | 10 | 10 | 15 | 60 | $7.38 |

Current Corps guidance for UDV (Economic Guidance Memorandum 06-3) includes tables to convert recreation point values into dollar-based unit day values. As shown in Table 5-5, the points assigned to hunting/fishing and general recreation for Lake Okeechobee convert to UDVs of $8.41 and $7.38, respectively. These values were applied to the FY 2005 visits derived from the OMBIL. The number of visit to Okeechobee Waterway in FY 2005 was 1,104,087. Twenty eight percent of the total visits or 309,144 visits were assigned to hunting and fishing and 72% or 794,943 were assigned to general recreation. As a result of this procedure, the total value of recreation at Lake Okeechobee in 2005 was estimated at $8,466,580, calculated as [(309,144*$8.41)+(794,943*$7.38)].

## 5.5 POTENTIAL EFFECTS OF ALTERNATIVE REGULATION SCHEDULES

The potential effects of the alternative regulation schedules on the quality and quantity of recreation depends on the frequency of change from the current regulation schedule and the sensitivity of existing recreation facilities and activities to these changes. No additional facilities are being contemplated as part of the LORSS project. In the case of the Lake Okeechobee Waterway, the quantity of recreation activities primarily refers to the ability of visitors to access the lake's recreation resources. The quality of recreation activities refers to how much enjoyment or satisfaction those activities produce. Finally, there are recreational safety issues that also may be sensitive to changes in lake levels.

### 5.5.1 Quantity Of Recreation Participation

Fluctuations in lake levels can affect the quantity of recreation participation on Lake Okeechobee. As an indicator of the sensitivity of recreation to lake levels, lake levels (measured to two decimal places) are posted daily on the front pages in newspapers of lakeside communities, such as the Clewiston News. Low lake stages can affect lake recreation in two principal ways. First, lake levels determine areas of Lake Okeechobee that are accessible to boaters and fishermen. Specifically, access to much of the lake's littoral zone, which occupies approximately 25 percent of the lake area, can be reduced during low lake stages. According to discussions with local boaters, many anglers and boaters will not go out on Lake Okeechobee when lake levels are below 11 ft. NGVD since access to many fishing locations is not possible. However, the difficulties faced by boat anglers during very low lake levels are somewhat offset by increased opportunities for anglers to wade from shore. Second, some of the boat ramps on Lake Okeechobee would be inoperable below 10 ft. NGVD. However, the depths of Lake Okeechobee at these extremely low lake stages would probably curtail boating activity before lake access via the ramps became a problem, particularly on the western side of the lake. The ramps at Corps recreation sites along the waterway typically extend from 9 ft. to 21.5 ft. NGVD. In addition, these specifications are recommended to state and local governments when they construct or rehabilitate boat ramps on the waterway. Discussions with boaters launching from the ramps on this waterway indicated that two feet of water is required at the bottom of the ramp to launch the small (bass) fishing boats that are typically used on Lake Okeechobee.

The spot soundings of boat ramps conducted as part of the 1998 study identified some boat ramps that were sensitive to lake levels. Four ramps have terminus depths below five feet; nine ramps had terminus depths between five and seven and a half feet; and five ramps had depths in excess of seven and a half feet. The lake stage at the time of the soundings was 15.2 ft. NGVD.

Therefore, some of the ramps would be inoperable at the lowest lake levels (10 ft. NGVD). This could potentially inconvenience some ramp users, but they could access the lake via nearby substitute ramps.

### 5.5.2 Quality Of Recreation Activities

The quality of recreation on the Lake Okeechobee Waterway is also subject to fluctuations in lake levels. Of the various lake-related recreation activities, sportfishing may be the most sensitive to changes in lake levels.

Fluctuations in lake stage have complex effects on fish stocks in Lake Okeechobee. Prior to 1900, Lake Okeechobee was clear with a sandy bottom. Lake stages varied with the season as overflow from the lake fed the southward sheetflow into the Everglades. However, construction of the levee system around Lake Okeechobee eliminated lake overflow and facilitated backpumping of nutrient-rich water from the EAA. In the last 30 years, rising nutrient levels have degraded water quality in Lake Okeechobee, and the lake has become increasingly eutrophic. More than one-half of the lake bottom is now covered with mud. In addition, periodic increases in lake stages (made possible by the levee system) have diminished the habitat quality of the littoral zone.

Under natural conditions, the variations in lake stages supported a diversity of plant communities in the littoral zone, providing high-quality fish and wildlife habitat. A given stage of Lake Okeechobee can have both positive and negative effects on fish and wildlife habitat. On the positive side, low lake stages:

- Allow muck to consolidate on the exposed lakebed thereby improving water quality and benthic habitat;
- Permit emergent vegetation to extend further into the lake, cleansing the water column; and,
- Enable the Florida Fish and Wildlife Conservation Commission to conduct controlled burning of exotic (i.e., non-native) species such as torpedo grass, hydrilla, and cattails; and allowing native plants to recolonize the area.

On the negative side, low lake stages can:

- Reduce access of fishermen to the lake, and
- Kill desirable aquatic vegetation, such as bullrush and eelgrass (although undesirable exotics are also killed when their habitat is drained).

High lake stages also have mixed effects. On the positive side, high lake stages are desirable since they kill undesirable exotic vegetation, such as hydrilla. On the negative side, desirable aquatic vegetation is also adversely impacted by high lake stages.

The ecological effects of changes in lake stages must be evaluated from both the short-term and long-term perspectives. For example, recreational fishing may suffer in the short-term when lake stages are low, since the water is warmer and many gamefish are forced from shallow to deep water. However, long-term benefits to fishing from the drawdown can be realized the following year as fish stocks increase due to habitat improvements. Similarly, high lake stages may increase fishing in the short-term by allowing better access to Lake Okeechobee, but the inundation of the littoral zone may have adverse effects on fishing the following year as a result of its diminished function as a fish nursery.

Among the causal factors for the ecological decline of the littoral zone are excessive fluctuations in lake stage, including the extent and duration of the fluctuations. From an ecological perspective, Lake Okeechobee lake stages are generally higher than desirable during the wet season (June through August) and generally lower than desirable during the dry season (October through March). While some lake stage fluctuations are desirable for purposes of fish and wildlife habitat, the net positive effects begin to erode when the fluctuations inundate or expose the littoral zone to the point of causing short-term and long-term stress on desirable fish and wildlife habitat.

### 5.5.3 Simulated Effects of Alternatives

Table 5-6 presents the simulated effects of the alternative regulation schedules on Lake Okeechobee stages. The simulated effects for the number of times stage is less than 12 feet for more than one year for each alternative regulation schedule is two while it is one for the current regulation schedule, 07LORS. The number of years stage is less than 11 feet for more than 100 days is very similar among all the alternative regulation schedules but approximately two and a half to three times greater than the current regulation schedule, 07LORS. None of the alternative regulation schedules are an improvement over the 07LORS with respect to these lake stage performance measures. Although the number of years stage is less than 11 feet for greater than 100 days is almost two and a half to three times greater than the current 07LORS, the magnitude in terms of percentage change in duration over a period of analysis of 13,140 days is relatively small. For example, the change from 07LORS to Alternative 1aS2-A in the number of days that the lake stage is below 11 feet increases by 879 days. This represents a 6.7 percent increase over the 36-year period of analysis. Alternative 1aS2-B has the least change from 07LORS while Alternative 2a-m has the greatest change. The change from 07LORS to Alternative 2a-m in the number of days that the lake stage is below 11 feet increases by 1,286 days. This represents a 9.8 percent increase from 07LORS to Alternative 2a-m over the 36-year period of analysis. Although the percent increase over the 36-year period of analysis from 07LORS is greater for Alternative 2a-m than for Alternative 1aS2-A, the difference between the two alternatives of 3.1 percent is very small.

**TABLE 5-6**
**SIMULATED EFFECTS OF ALTERNATIVE REGULATION SCHEDULES ON LAKE OKEECHOBEE STAGES LESS THAN 11 AND 12 FEET NGVD**

| Stage Measures | 07LORS | 1bS2-A | 1bS2-m | 4-A | 2a-B | 2a-m |
|---|---|---|---|---|---|---|
| Number of times lake stage < 12 ft. NGVD for > 1 year | 1 | 2 | 2 | 2 | 2 | 2 |
| Number of times lake stage < 11 ft. NGVD for > 100 days | 3 | 7 | 7 | 8 | 9 | 9 |
| Number of days lake stage is below 11 ft. NGVD | 524 | 1403 | 1427 | 1494 | 1576 | 1810 |
| Increase in days for lake stage below 11 ft. Alternative from 07LORS | | 879 | 903 | 970 | 1,052 | 1,286 |
| Percentage Increase for lake stage below 11ft. over 36 years of record | | 6.7% | 6.9% | 7.4% | 8.0% | 9.8% |

Fishery biologists of the Florida Fish and Wildlife Conservation Commission (FFWCC) and sport fisherman on Lake Okeechobee indicate that low lake levels reduce the quantity and quality of the lake’s littoral zone and thereby adversely affect critical spawning habitat. Conversely, high water levels on Lake Okeechobee can also impact the sport fishery by inundating the littoral zone of the lake. Concerns about the effects of high water levels in the littoral zone on fish and wildlife (especially bird) habitat was one of the reasons that the LORSS was initiated. Although it is agreed that low lake stages are detrimental to Lake Okeechobee’s ecology, the U.S. Fish and Wildlife Service (USF&WS) believes that high lake stages are far more detrimental to Lake Okeechobee’s ecology than the low stages. The alternative regulation schedules were designed to have fewer high lake stages than the current regulation schedule. As shown in Table 5-7, the number of times that lake stage is above 17.25 feet for more than seven consecutive days for each alternative is as follows: 07LORS is 6; alternative 1bS2-A is 1; and alternatives 1bS2-m, 4-A, 2a-B and 2a-m is zero. The number of times that lake stage is above 17 feet for each alternative is as follows: 07LORS is 9; alternative 1bS2-A, 1bS2-m and 4-A are 2; and alternatives 2a-B and 2a-m are 1.

**TABLE 5-7**
**SIMULATED EFFECTS OF ALTERNATIVE REGULATION SCHEDULES ON LAKE OKEECHOBEE STAGES GREATER THAN 17 FEET NGVD**

| Stage Measures | 07LORS | 1bS2-A | 1bS2-m | 4-A | 2a-B | 2a-m |
|---|---|---|---|---|---|---|
| Number of times lake stage > 17.25' NGVD for > 7 days | 6 | 1 | 0 | 0 | 0 | 0 |
| Number of times lake stage > 17' NGVD | 9 | 2 | 2 | 2 | 1 | 1 |
| Number of days lake stage is greater than 17' NGVD | 476 | 29 | 24 | 23 | 11 | 5 |
| Decrease in days for lake stage greater than 17' Alternative from 07LORS | | 447 | 452 | 453 | 465 | 471 |
| Percentage decrease for lake stage greater than 17' Alternative from 07LORS | | 93.9% | 95.0% | 95.2% | 97.7% | 98.9% |

There is a significant reduction in the number of times lake stages are over 17.25 feet for greater than seven days and greater than 17 feet for between the 07LORS and each alternative, but the change between one alternative and another is relatively small. According to the USF&WS, the positive changes in Lake Okeechobee's ecology from the reduced number of high lake stages outweighs the negative changes in the lake ecology from the increased number of low lake stage. As shown in Table 5-7, the percentage decreases in days that lake stages are greater than 17 feet from the 07LORS regulation schedule to the alternative regulation schedules ranges from 93.9 to 98.9 percent.

These high and low water conditions affect fishing either directly or indirectly, but there are also short-term considerations regarding whether the fish are "biting." Local anglers report that the quality of the fishing declines significantly when Lake Okeechobee's levels get low, water temperatures rise, and dissolved oxygen levels fall. Discussions with sport fishermen on Lake Okeechobee yield a variety of opinions regarding the critical threshold when lake levels begin to affect the quality of fishing. In general, this threshold was reported to be approximately 13 ft. NGVD.

The relationship between quality of fishing and lake levels has several qualifying factors. First, low lake levels are important relative to the quality of fishing for particular sportfish at different times of the year. The quality of fishing for particular species varies with the seasons. If low water occurred at a time when the fishing was not particularly good, the effects of the low water on fishing would be less, relative to other times of the year. A second qualifying factor is that low lake levels do not affect the quality of fishing for all sport species. While the quality of bass fishing may suffer as access to the lake's littoral zone is reduced, crappie fishing may be relatively unaffected, since crappie are usually caught in deep water.

### 5.5.4 Recreational Safety

Recreational hazards on Lake Okeechobee can be exacerbated by lower lake levels. The potential for vessels to run aground increases as lake levels fall. The hazards to recreational navigation are greater than for commercial traffic, since commercial traffic generally follows designated channels, and recreational boaters move freely around Lake Okeechobee. On most occasions, there are no injuries, and the boats are not damaged by the soft bottom of Lake Okeechobee. However, there are occasions where life and property are at risk, especially during inclement weather. Long exposures to large waves can severely damage or destroy grounded vessels, leaving boaters at risk. Based on conversations with Corps operations personnel who are often called upon to assist grounded vessels, groundings in lake levels above 12 ft. NGVD are infrequent, perhaps several groundings per month. However, below 12 ft. NGVD, the frequency of groundings increases substantially, to as many as several groundings per day. The timing of the low lake levels is again a critical factor with respect to this safety issue. During the winter months, when tourist activity is highest, there are a large number of vessels on the lake, many of the operators are relatively inexperienced, and the likelihood of groundings is higher.

Another recreational safety issue that is affected by lake level fluctuations is wave action on Lake Okeechobee. Even at its highest levels, Lake Okeechobee is subject to hazardous wave action, since it is so shallow. According to local boaters, the wave action on Lake Okeechobee substantially increases as lake levels drop, increasing the risk to recreation vessels.

## 5.6 ASSESSMENT

There are a variety of issues regarding recreational quantity and quality that are sensitive to changes in low and high lake levels. These include access of boaters and anglers to Lake Okeechobee, movement around the lake, the quality of their recreation experience, and their safety while participating in these recreational activities. The quantity and quality of recreation on Lake Okeechobee begins to reduce as lake levels fall below 13 ft. NGVD. Below lake stage 11 feet, many anglers and boaters will not go out on the lake since access to many fishing locations is not possible. Lake Okeechobee would experience low levels under both with- and without-project conditions. The incremental differences associated with the alternative plans relative to the 07LORS plan over the 36-year period of analysis range from 6.7 to 9.8 percent for the number of days lake stage is below 11 feet and 17.1 to 24.5 percent for the number of days lake stage is below 12.56 feet. The 12.56 feet lake stage is around the range where quantity and quality of recreation on Lake Okeechobee begins to reduce. The 17 to 25 percent increase in the numbers of days that lake stage is below 12.56 ft. NGVD may have a minor adverse impact on visitation. When lake stage is below 11 feet, there may be additional, but only minor adverse effects on recreation quantity since the quality of the recreational experience has already been significantly reduced to the point where the majority of boaters and anglers have ceased recreational activities.

As discussed previously in this chapter, the quality and quantity of recreation declines when lake levels fall below 13 ft. NGVD. Therefore, as shown in Table 5-8, the performance measure of the percentage change in number of days of stage events less than 12.56 feet would be a useful indicator of recreation impacts. The performance measure of the percentage change in number of days that stage is greater than 17 feet would be a useful indicator to observe the long-term improvements of Lake Okeechobee's ecology. However, this analysis focuses on the short-term recreation impacts of the alternative regulation schedules. It does not reflect the important role of a healthy littoral zone in maintaining the long-term health of the fishery. Therefore, the negative impacts of an increase in the number of days will be measured in this analysis.

A scenario was constructed to assess the economic sensitivity of recreation to changes in lake levels. As shown in Table 5-8, the performance measure of the percentage change in number of days that stage is less than 12.56 feet was used to determine the economic impacts of each alternative compared to the 07LORS regulation schedule. The additional days below lake stage 12.56 feet were calculated into percentage change over a 36-year period.

**TABLE 5-8**
**SIMULATED EFFECTS OF ALTERNATIVE REGULATION SCHEDULES ON LAKE OKEECHOBEE STAGES BELOW 12.56 FEET NGVD**

| Stage Measures | 07LORS | 1bS2-A | 1bS2-m | 4-A | 2a-B | 2a-m |
|---|---|---|---|---|---|---|
| Number of days lake stage is below 12.56 ft. NGVD | 2557 | 4809 | 4842 | 4841 | 5141 | 5776 |
| Increase in days for lake stage below 12.56 ft. Alternative from 07LORS | | 2,252 | 2,285 | 2,286 | 2,584 | 3,219 |
| Percentage Increase for lake stage below 12.56 ft. Over 36-years of analysis | | 17.1% | 17.4% | 17.4% | 19.7% | 24.5% |

In order to estimate the additional losses in benefits to recreation at different lake stages, information regarding the number of visits that would not occur because of the change in lake stage must be known. This information is not readily available. Therefore, the magnitude of the negative impact of each alternative is unknown.

Since there is no reliable data that shows the change in number of visits when lake stages are below 12.56 feet and since no benefit to cost ratio is required for this economic analysis, it can be determined that the alternative with the least increase in the number of days for lake stage below 12.56 ft. NGVD is the alternative with the least negative impacts to the project. This would be Alternative 1bS2-A since it only has a 17.1 percent increase in number of days over the

36-year period of analysis from the 07LORS plan when lake stage is below 12.56 feet. The worst negative impact would be with Alternative 2a-m with a 24.5 percent increase in number of days from the 07LORS plan when lake stage is below 12.56 feet.

Based on Table 5-8, the ranking of alternatives from best to worst is as follows: 07LORS; Alternative 1bS2-A; Alternative 1bS2-m; Alternative 4-A; Alternative 2a-B; and Alternative 2a-m.

# 6. COMMERCIAL FISHING

## OVERVIEW

Lake Okeechobee is home to an active commercial fishing industry. This includes several different types of commercial fishing operations and landside support activities, such as marinas and fish houses, which purchase the catch for wholesale and retail distribution. Large scale commercial fishing began in Lake Okeechobee around 1900 with the use of haul seines as primary gear, although trotlines, pound nets, and wire traps were also utilized. Catfish were the most commonly sought species by commercial fishermen. Other species such as bluegill, redear sunfish, and black crappie, as well as largemouth bass and mullet were also taken.

In 1916 the Florida Legislature imposed the first regulation on the industry, including a four-month closed season on haul seines, a maximum haul seine length, and a minimum haul seine mesh. Despite these initial regulatory efforts, commercial catches waned, due in part to over-fishing and in part to man-made changes in Lake Okeechobee. The levee on the southern shore of Lake Okeechobee prevented fish from entering adjacent marshes to spawn. Additionally, the emerging sport fishing industry began to push for increased regulation of the commercial fishing industry, claiming that commercial harvesting of game fish, particularly by haul seining, was detrimental to game fish populations. As a result, commercial fishing became increasingly regulated throughout the 1950's, with stronger restrictions on commercial harvest of game fish and limits on the use of commercial gear.

In 1976, the Florida Game and Freshwater Fish Commission (Commission) authorized a commercial fishing program with the joint goals of improving lake water quality and restoring the sport fishery. The Commission recognized that commercial fish removal was a practical tool to improve the structure of game fish populations, as well as to remove nutrients (nitrogen and phosphorus) from Lake Okeechobee. The commercial harvest and sale of freshwater game fish (except black bass and chain and redfin pickerel) and the use of haul seines and trawls were approved. Initially, 40 haul seine permits and 200 trawl permits were issued. To avoid conflicts with popular sport fishing areas, haul seines and trawls were prohibited from operating within one mile of emergent (shoreline) vegetation.

In 1981, a severe drought resulted in historically low water levels in Lake Okeechobee. The lake's littoral zone was almost entirely drained, forcing fish populations from the shallows into deeper, open water. Widespread concern that the commercial fishing industry would over-harvest the dislocated fish populations led the Commission to temporarily suspend the use of haul seines and trawls for the harvest of game fish. In November 1982, the harvest and sale of some game fish (primarily bluegill and redear sunfish) and the operation of ten haul seines were re-authorized. Trawl permits and the commercial harvest and sale of black crappie were not re-authorized.

Except for a 1995 state-wide ban on the commercial harvest of striped mullet, regulation of the commercial fishery has remained unchanged since 1982. Commercial fishing activity is banned on weekends and holidays, but otherwise occurs year round. The three primary gear types utilized on Lake Okeechobee are haul seines, trot lines, and wire traps. Haul seines are used to fish primarily for bream, although the by-catch (i.e., catfish, bullhead, shad and gar) must also be kept. Most of the current haul seiners operate out of Clewiston, although one operator is located in Pahokee. Daily haul seine harvests are accepted at four local fish markets: Jones Fish Company, Rudd's Fish House, Met's Mouth of the South, or B&R Fish House. Haul seine fishermen are responsible for filing weekly harvest reports with the Commission.

Commercial fishermen using trotlines or wire traps on Lake Okeechobee fish primarily for catfish. Gear regulations do not restrict the length of trotlines, however, each line is limited to a maximum of 500 individual hooks. Wire trap designs are restricted to two funnels at one end. Maximum trap dimensions must not exceed seven feet in length or 32 inches in width. Additionally, the minimum mesh size for wire traps is one inch, and all wire traps must be submerged a minimum of five feet. Commercial harvests by trotliners are taken at two fish houses in Okeechobee (Stoke's and Dean's) and one fish house in Pahokee (Jones Fish Co.). Jones Fish Co. also accepts catch by wire trap. Fishermen using either wire traps or trotlines on Lake Okeechobee must have a State commercial fishing license. Because commercial fishing licenses are not specific to a particular fishery, the number of trotliners and wire trappers on Lake Okeechobee cannot be determined from license data. However, catch by gear type is recorded for Lake Okeechobee through reports that must be filed by each fish house with the Commission. Annual commercial fish harvests by species and gear type from 1986 to 1996 are contained in Table 6-1.

As part of the field investigation for this study, interviews with commercial fishermen, fish houses, and the Florida Fish and Wildlife Conservation Commission (FFWCC) were conducted to determine the scope of commercial fishing on Lake Okeechobee and assess its sensitivity to the potential changes in lake levels resulting from the alternative regulation schedules. Several fish houses were interviewed to determine current market prices (wholesale) in order to estimate commercial fishing income. The following average market prices were obtained from the fish houses: catfish ($.40/lb.), bream ($.90/lb.), shad ($.25/lb.), and tilapia ($.25/lb.). Based upon these prices the annual value of the wholesale commercial fishery is $2,326, 932.

In his 1987 study of the economic effects of commercial fishing on Lake Okeechobee, Bell (1987) estimated that there were a total of 210 jobs associated with commercial fishing in Lake Okeechobee. These included 190 jobs for fishermen using all types of gear and 40 landside jobs in local fish houses.

There is a continuing controversy in the Lake Okeechobee region regarding the compatibility of commercial fishing and sport fishing. Some sport fishermen accuse the commercial fishermen of degrading the sport fishery with excessive harvests. The FFWCC has conducted a variety of studies that suggest that commercial fishing actually benefits sport fishing by removing non-sport species and reducing nutrient levels in Lake Okeechobee that these species have absorbed. In general, the sport fishermen are skeptical, but the Commission has maintained that the sport fishery has thrived in recent years despite commercial fishing.

**TABLE 6-1**
***COMMERCIAL FISH HARVEST (pounds)***
**LAKE OKEECHOBEE, 1986-1996**

| **TROTLINE** | **White Catfish** | **Channel Catfish** | **Brown Bullhead** | **Yellow Bullhead** | **Bluegill** | **Redear Sunfish** | **Shad** | **Gar** | **Striped Mullet** | **Tilapia** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1986-1987 | 2,061,860 | 266,814 | 34,058 | 0 | | | | | | | **2,362,732** |
| 1987-1988 | 1,993,339 | 30,896 | 20,816 | 1,367 | | | | | | | **2,046,418** |
| 1988-1989 | 2,174,885 | 160,837 | 27,159 | 247 | | | | | | | **2,363,128** |
| 1989-1990 | 1,666,426 | 223,882 | 38,267 | | | | | | | | **1,928,575** |
| 1990-1991 | 1,495,038 | 350,641 | 45,448 | | | | | | | | **1,891,127** |
| 1995-1996 | 1,504,830 | 372,966 | 84,443 | 2,293 | | | | | | | **1,964,532** |
| **HAUL SEINES** | | | | | | | | | | | |
| 1986-1987 | 202,399 | 78,527 | 133 | | 532,361 | 178,005 | 588,232 | 70,788 | 119,390 | | **1,769,835** |
| 1987-1988 | 386,633 | 27,489 | 1,664 | | 386,498 | 205,563 | 499,374 | 97,485 | 264,222 | | **1,868,928** |
| 1988-1989 | 320,384 | 22,362 | 9,647 | | 700,300 | 119,218 | 361,834 | 86,803 | 176,294 | | **1,796,842** |
| 1989-1990 | 295,981 | 162,051 | 72,497 | | 717,250 | 272,364 | 521,245 | 100,766 | 167,388 | | **2,309,542** |
| 1990-1991 | 430,064 | 251,862 | 25,970 | | 875,319 | 265,253 | 409,061 | 252,407 | 164,257 | | **2,674,193** |
| 1995-1996 | 877,047 | 138,433 | 107,161 | | 625,329 | 276,735 | 1,557,969 | 295,190 | | 136,308 | **4,014,172** |
| **WIRE TRAP** | | | | | | | | | | | |
| 1986-1987 | 38,751 | 188,033 | 33,310 | | | | | | | | **260,094** |
| 1987-1988 | 208,076 | 135,536 | 43,563 | 85 | | | | | | | **387,260** |
| 1988-1989 | 62,182 | 11,173 | 17,353 | 1,792 | | | | | | | **92,500** |
| 1989-1990 | 34,700 | 22,349 | 6,109 | 23 | | | | | | | **63,181** |
| 1990-1991 | 52,732 | 7,189 | 2,094 | | | | | | | | **62,015** |
| 1995-1996 | 20,467 | 8,509 | 4,401 | | | | | | | | **33,376** |
| **ALL GEAR** | | | | | | | | | | | |
| 1986-1987 | 2,303,010 | 533,374 | 67,501 | | 532,361 | 178,005 | 588,232 | 70,788 | 119,390 | | **4,392,661** |
| 1987-1988 | 2,588,048 | 193,921 | 66,043 | 1,452 | 386,498 | 205,563 | 499,374 | 97,485 | 264,222 | | **4,302,606** |
| 1988-1989 | 2,557,451 | 194,372 | 54,159 | 2,039 | 700,300 | 119,218 | 361,834 | 86,803 | 176,294 | | **4,252,470** |
| 1989-1990 | 1,997,107 | 408,282 | 116,873 | 23 | 717,250 | 272,364 | 521,245 | 100,766 | 167,388 | | **4,301,298** |
| 1990-1991 | 1,977,834 | 609,692 | 73,512 | | 875,319 | 265,253 | 409,061 | 252,407 | 164,257 | | **4,627,335** |
| 1995-1996 | 2,402,343 | 519,908 | 196,005 | 2,293 | 625,329 | 276,735 | 1,557,969 | 295,190 | | 136,308 | **6,012,080** |

Source: Florida Game and Freshwater Fish Commission.

## 6.1 POTENTIAL EFFECTS ON COMMERCIAL FISHING IN LAKE OKEECHOBEE

Changes in lake levels associated with the alternative regulation schedules could impact commercial fishing operations and/or the stocks of commercial fish. Fluctuations in lake levels could also potentially affect landside support services. The purpose of this analysis is to determine whether commercial catch or operating costs would be affected by the alternative regulation schedules and, if so, to quantify the NED effects of these changes.

The NED account registers changes in net income from commercial fishing operations. Net income changes result from either changes in the size of the catch (net revenues) and/or changes in the cost of catching the fish (net operating costs). The LORSS alternatives are not anticipated to affect the overall size of the Lake Okeechobee fishery or the amount of the commercial fishing catch. In fact, the single greatest determinant in the size of the fishing catch (and net fishery revenues) are the complex series of operational restrictions placed on the fishery by FFWCC.

The cost of catching fish (net operating costs) could potentially be changed if the LORS were modified. Interviews with commercial fishermen on Lake Okeechobee were conducted to: (1) evaluate the operations and economics of commercial fishing on the lake and (2) determine the sensitivity of commercial fishing to changes in lake levels associated with the alternative regulation schedules. The interviews with commercial fisherman were conducted with haul seiners. Questions about commercial fishing with trotlines and wire traps were answered by representatives of the FFWCC field office in Okeechobee, on the north side of Lake Okeechobee.

The total number of haul seine permits are limited to ten in order to keep fish yields sustainable. The profitability of the haul seine operations are indicated by the long waiting list for permits reported by the FFWCC. Although some of the vessels are larger, most of the haul seine operations use vessels with lengths of approximately 35 feet and drafts of four to five feet, depending on the vessel and the size of the catch in the hold. In general, the seiners prefer low lake levels to high lake levels. The reason is based on their equipment. The seines are set by driving a metal pole into the lake bottom with one end of the seine attached. The fishing boat then motors away laying the seine in a large arc. The boat slowly completes the circle as it returns to the pole. Another pole is driven adjacent (approximately one foot distance) to the first. The net is pulled through the space between the poles, slowly closing it around the enclosed fish. The fishermen report that deeper waters are problematic for haul seines, because deeper waters require larger poles which are more difficult to drive into the lake bottom. Fishermen also indicated that they do not like to fish in deep waters of Lake Okeechobee, since the nets will sink into the muddy bottom. It is possible for haul seines to be used at depths over 20 feet, but some fishermen would need to purchase new nets, and the costs are compounded by the physical challenge of using haul seines in deeper water.

The haul seiners prefer lake levels that are in the 13 to 14 ft. NGVD range. Lower lake levels constrain the haul seiner’s movements around the lake. Higher lake levels make haul seiner’s gear more difficult to use and induce the fish to move into shallow waters that are inaccessible to commercial fishermen. In addition, the commercial fishermen recognize that very high or very low lake levels inundate or drain the littoral zone which is critical to fish spawning. The higher water temperatures of low water were also cited as adversely impacting spawning.

The haul seiners operate year round. The haul seine licenses require that fishermen fish at least 120 days per year. Fishermen apparently do not fish much more than this due to adverse weather considerations on Lake Okeechobee. If winds are in excess of 15 knots, the fishermen generally will not leave port, since waves on Lake Okeechobee are so problematic. The connection between increased wave formation and lower lake levels was also cited by these fishermen.

Fishermen who use trotlines and wire nets generally prefer high water conditions since these fishermen operate in the deeper waters of Lake Okeechobee to harvest catfish. Bell (1987) estimated that there were approximately 80 trotline fishermen operating on Lake Okeechobee. According to Commission representatives, there are only a few fishermen who use wire nets, and these fishermen are required by their fishing licenses to have at least five feet of water overhead. Wire net fishermen generally prefer water depths that are approximately eight feet (which is the authorized channel depth in Lake Okeechobee at lake level 14.56 ft. NGVD).

## 6.2 ASSESSMENT

In general, commercial fishing on Lake Okeechobee is not very sensitive to changes in lake levels. The operating draft of commercial fishing vessels are sufficiently shallow to allow access to Lake Okeechobee throughout the range of lake levels anticipated with the alternative regulation schedules. While fishermen seem to prefer lake levels in the intermediate range, most would prefer to have lower lake levels to higher lake levels.

In terms of the size of fish stocks, the ecological effects of the alternative regulation schedules could potentially affect the number of fish and mix of species in Lake Okeechobee. The alternative regulation schedules are all expected to improve habitat conditions in Lake Okeechobee's littoral zone by reducing the extent and duration of extreme lake stages relative to the future without-project condition. This would probably translate into an increase in the size of commercial fish stocks. The commercial fishermen interviewed indicated that very high or very low lake levels inundate or drain the littoral zone which is critical to fish spawning. The higher water temperatures during low water periods were also cited as adversely impacting spawning.

Despite the positive ecological effects of the alternative regulation schedules, it is unlikely that the resulting marginal increase in fish stocks will significantly affect the size of the commercial fish catch. The single greatest determinant of the size of the fishing catch (and net fishery revenues) is the complex series of operational restrictions placed on the fishery by FFWCC to promote a sustainable commercial harvest. These regulations are not expected to change between the with- and without-project conditions. It is unlikely that the GFWFC will allow a significant increase in the commercial harvest following implementation of the regulation schedules.

In terms of physical access to the fishery, the operating drafts of commercial fishing vessels on Lake Okeechobee are sufficiently shallow to access commercial stocks throughout the range of lake levels anticipated with the alternative regulation schedules. However, there may be some marginal benefits realized by reducing the costs of fishing operations, since fishermen seem to prefer lake levels in the intermediate range and the alternative regulation schedules are anticipated to moderate lake stage fluctuations.

Regulation of the fishery by the GFWFC appears to be the most significant determinant of both the size of the commercial catch and the net income of commercial fishermen. While the GFWFC has shown in the past (e.g., 1981) that it will modify the restrictions on the fishery in response to extreme changes in lake levels, it is not anticipated that any similar action would be taken in the foreseeable future. Commercial fishing on Lake Okeechobee currently appears to be at sustainable levels. Therefore it is unlikely that any regulatory changes would be made in response to the modest effects anticipated from implementation of any of the alternative regulation schedules.

# 7. COMMERCIAL AND RECREATIONAL FISHING IN THE CALOOSAHATCHEE AND ST. LUCIE ESTUARIES

## OVERVIEW

The alternative regulation schedules for Lake Okeechobee were formulated to keep lake levels low in the wet season (June to October) to provide flood and hurricane protection; and to keep levels high in the dry season (November to May) for water supply purposes. Lake Okeechobee has four principal outlets for discharging inflows received from its tributary waterways: (1) evaporation, which in the south Florida climate accounts for 70 percent of the lake's water loss, (2) the distributary canals that convey water southward to the LEC and the Everglades, (3) the Atlantic Ocean via the St. Lucie canal, and (4) the Gulf of Mexico via the Caloosahatchee River. The quantity, quality, and timing of the releases to the St. Lucie and Caloosahatchee estuaries are critical determinants of the diversity and productivity of those ecosystems. The purpose of this chapter is to interpret the economic consequences of the alternative regulation schedules. The potential economic consequences could be manifested through changes in the hydrologic regimes of the outlet waterways and resultant ecological effects on the estuarine ecosystems.

## 7.1 EFFECTS OF LAKE RELEASES ON ESTUARINE ECOLOGY

These two estuaries are highly productive ecosystems that exist at the interface between freshwater and seawater. The St. Lucie Estuary is a small estuary of approximately 6,000 acres located in Martin and St. Lucie counties. The North and South Forks, which constitute the inner estuary, converge at the City of Stuart where the river widens to one mile after passing beneath the Roosevelt Bridge. Approximately three miles east, the river bends to the south, extending to the southernmost extension of Sewell Point, a spit of land separating the St. Lucie River from the Indian River Lagoon to the east. At Sewell Point, both bodies of water empty into the Atlantic Ocean at the St. Lucie Inlet.

The Caloosahatchee Estuary is part of the southern portion of Charlotte Harbor, which includes the estuary, San Carlos Bay, Pine Island Sound, and Matlacha Pass. The estuary extends 29 miles from the W.P. Franklin Lock and Dam near Alva to Shell Point at its mouth in San Carlos Bay. San Carlos Bay, which is bounded by Sanibel Island and Pine Island, is located at the confluence of the river, Pine Island Sound, Matlacha Pass, and the Gulf of Mexico. The freshwater releases into the estuary are controlled by the Franklin Lock and Dam, which also serves as a barrier to salinity and tidal influences upstream.

The quantity, timing, and quality of freshwater inputs to estuaries are critical determinants of the structure and function of these ecosystems (Bulger et al., 1990). Freshwater flows provide critical functions and materials for estuaries, including:

- Nutrients for estuarine biota;
- Protection from predation by mature life stages that are intolerant of lower salinities or that are unable to find prey in naturally turbid estuarine waters;

- A range of salinity conditions for a variety of organisms with different requirements for growth and development; and
- Transportation and deposition of many estuarine-dependent larvae.

Relative to natural conditions, the releases from Lake Okeechobee and changes in the watersheds have significantly altered freshwater inputs to the St. Lucie and Caloosahatchee estuaries and have adversely affected the structure and function of these sensitive ecosystems. In general, the peak flows from Lake Okeechobee to these estuaries are higher than those under natural conditions, and the low flows are lower.

The changes in freshwater inputs to the estuaries have short-term and long-term effects on these ecosystems. The most immediate effect of these changes is the magnification of the natural fluctuations of salinity in these estuaries. Estuarine species evolved under conditions of naturally fluctuating salinity levels, but excessive fluctuations can stress these ecosystems. As described by Bulger et al. (1990), excessive salinity fluctuations can keep estuarine biota in constant flux between organisms which favor higher salinity and those which favor lower salinity. If the fluctuations are extreme, appropriate salinity conditions do not last long enough for organisms to complete their life cycle, and the diversity of organisms is reduced to those few species which can tolerate the dramatic salinity fluctuations.

Even moderate releases (such as in Zone B of the LORS) can transform these estuarine systems into freshwater habitats after a few weeks of sustained releases. The estuarine species are displaced or expire during extended periods of low or high salinity. In addition, continuous flow releases tend to create critically low benthic oxygen levels at the transition zone between freshwater and seawater. These ecosystem perturbations affect more than just estuarine species, since estuaries provide critical nursery habitat for marine (offshore) finfish and invertebrate species. These adverse effects provided the impetus for instituting the pulse releases contained in Zone C of the LORS.

In general, when regulatory releases are terminated, the salinity levels in these estuaries return to the normal range, and the ecosystems begin to recover. The estuarine species that were displaced or extirpated return or are replaced. The recovery period is commensurate with the rate and duration of the freshwater inputs to the estuaries.

Other longer-term effects of the regulatory releases from Lake Okeechobee on the St. Lucie and Caloosahatchee estuaries include sediment and nutrient effects. Both effects are related to the quality of the water releases from Lake Okeechobee, which contain suspended silt, clay, and organic material. Much of the suspended material settles onto the bottom of the St. Lucie Canal and the Caloosahatchee River during modest, nonregulatory releases. However, during regulatory releases (particularly the high release levels in Zone B and Zone A of the LORS) this material is resuspended and carried into the estuaries during the first few days of the release period.

Suspended material increases the turbidity of the water in the estuaries and blocks sunlight to seagrass communities in these estuaries. Some seagrass communities are smothered by the suspended material as it settles in the low-energy environment of the estuaries. Other seagrass communities are affected by the reduction in sunlight that results from increased turbidity. Nutrient effects result from the nitrates and phosphorus contained in Lake Okeechobee's water which are resuspended by the release flows and stimulate primary production in the estuaries. Releases can imbalance nutrient cycling in these ecosystems, leading to algae blooms and subsequent declines in dissolved oxygen and further increases in turbidity.

The short-term and long-term ecological problems in these estuaries are not entirely attributable to the regulatory releases from Lake Okeechobee. These estuaries have perturbations from other sources that contribute to the stresses on these ecosystems. For instance, other estuarine tributaries deposit freshwater, sediments, and nutrients in these ecosystems, including heavy metals that are associated with agricultural pesticide use in the contributing watersheds.

## 7.2 FISHING AND OTHER ECONOMIC EFFECTS ON THE ESTUARIES

The ecological effects of the freshwater releases to the estuaries can lead to commercial and recreational fishing impacts. These potential economic effects are discussed below. There are other potential (non-fishing) economic effects from freshwater releases which are also associated with changes in estuarine water quality. These effects could include changes in: (1) waterfront property values if water quality degradation is severe or sustained and (2) the quantity or quality of recreation (and tourism) if the releases discolor the water at beaches or if the releases contribute to algae blooms that limit beach access. These nonfishing effects are beyond the scope of this investigation, but they are current sources of concern to local residents and businesses who enjoy the estuaries and depend on tourists who come to use them. For example, in the spring of 1998 the City of Sanibel received complaints from residents and tourists about the water quality effects of freshwater releases down the Caloosahatchee River and into San Carlos Bay and the Gulf of Mexico.

## 7.3 POTENTIAL EFFECTS ON FISHING IN ST. LUCIE ESTUARY

The potential economic effects of the alternative regulation schedules on fishing in the St. Lucie Estuary depend on how the hydrologic changes affect the ecology of the estuary and on how the ecological changes translate into changes in commercial and recreational fishing. The economic effects on commercial fishing might include changes in the size of the catch or the cost of fishing operations. For guided sportfishing, the economic effects might include changes in the income of the professional fishing guides. For recreational anglers, economic effects could result from changes in the quantity or quality of recreational fishing experiences. As evident in the discussions below, the linkages between the hydrology, ecology, and economics of fishing in the St. Lucie Estuary are highly uncertain. Nevertheless, the hydrologic information generated through the SFWMM simulations does have economic implications for fishing in the estuary.

As part of this investigation, a variety of individuals, organizations, and institutions were contacted to identify pertinent studies and individuals with expertise on the effects of Lake Okeechobee releases on the St. Lucie Estuary. Contacts included:

- Florida Oceanographic Society;
- Marine Research Council;
- Harbor Branch Oceanographic Institute;
- St. Lucie Initiative;
- St. Lucie River Coalition;
- Florida Marine Research Institute;
- Florida Sea Grant;
- Martin County;
- Indian River Lagoon National Estuary Program;
- Treasure Coast Regional Planning Council; and
- SFWMD.

### 7.3.1 Profile of Commercial and Recreational Fishing in the St. Lucie Estuary

A profile of commercial and recreational fishing in the St. Lucie Estuary can be constructed using field information and data from state and national fishing databases. Unfortunately, much of the available information about commercial and recreational fishing in the estuary is contained in studies and data sets for much larger geographic areas.

There is very little, if any, commercial fishing in the St. Lucie Estuary. The use of gill nets in Florida coastal waters was banned in 1994. Interviews with local fish houses (i.e., retailers) indicate that their supplies do not come from the estuary. However, there may be low levels of commercial fishing for finfish (using rod and reel or cast nets) and for crabs. In Martin County, there are 271 saltwater products licenses and 44 permits for blue crab fishing. Crabbing activity in the estuary is believed to be small.

Although there is little commercial fishing within the estuary proper, the St. Lucie Estuary has important ecological connections with offshore commercial fish stocks. As explored in Nelson et al. (1991), some commercial species of finfish and invertebrates inhabit estuaries year-round; however, a large number of species only use estuaries during portions of their life cycle. Most of these latter species fall into four general categories:

- Diadromous species, which use estuaries as migration corridors and, in some instances, nursery areas;
- Species that use estuaries for spawning, often at specific salinity levels;
- Species that spawn in marine waters near the mouths of estuaries and depend on tidal- and wind-driven currents to carry eggs, larvae, or early juveniles into estuary nursery areas; and,
- Species that enter into estuaries during certain times of the year to feed on abundant prey and/or utilize preferred habitats.

In 1990, the Indian River Lagoon, which adjoins the St. Lucie Estuary, was included in the National Estuary Program (NEP). The NEP targets nationally significant estuaries for assessment and development of management plans that will substantially enhance their ecological quality. While the NEP studies on Indian River Lagoon suggest that the freshwater flows from the St. Lucie Estuary may not significantly affect the lagoon, the studies do provide insight to the ecology of the St. Lucie Estuary. In particular, the Indian River Lagoon studies identified 20 species of commercial finfish and three species of shellfish (blue crab, hard clam, and oyster) in the lagoon that are estuarine dependent. The estuarine-dependent finfish include:

- Atlantic sheepshead;
- Bluefish;
- Croaker;
- Drum, black;
- Drum, red;
- Flounders;
- Jack, crevalle;
- King whiting;
- Mackerel, spanish;
- Menhaden;
- Mullet, silver;
- Mullet, striped;
- Permit;
- Pompano;
- Snapper, mangrove;
- Snapper, mutton;
- Snapper, yellowtail;
- Seatrout, spotted;
- Spot; and,
- Tripletail

Nelson et al. (1991) noted that the estuaries on Florida's east coast include large numbers of tropical Caribbean fauna. In addition, Nelson et al. determined that the number of species (including adults, juveniles, and larvae) in southeastern estuaries varies by season and by salinity zone. Estuarine utilization for all life stages is highest in summer and lowest in winter. The number of species present as larvae reaches a peak in April in the tidal freshwater, mixing, and seawater zones. In contrast, the numbers of juveniles and adults in the three zones peak during the summer months. In any given month, more species utilize these estuaries as juveniles than at any other life stage. Some common species, such as bluefish and gray snapper, are primarily found in the estuary as juveniles and adults, with spawning, eggs, and larval development occurring offshore. Other species, such as snook and tarpon, are tolerant of a wide range of salinity levels. Seasonal variations in species composition implies that the timing, as well as the quantity, of freshwater releases to the St. Lucie Estuary are critical determinants of their potential effects on the estuarine ecology.

The FFWCC, Fish and Wildlife Research Institute, maintains the Florida Marine Fisheries Information System, a database of commercial fish landings. Summaries of the 2001-2005 commercial landings for Martin County and St. Lucie County are presented in Table 7-2. The summaries include finfish, invertebrates, and bait shrimp. No shrimp landings were reported for Martin County and St. Lucie in 2004 and 2005. The poundage, trips, and value of finfish have varied widely over the last five years, with values ranging from one and one-half million dollars to more than four million dollars for Martin County and from more than two million dollars to more than five million dollars. In contrast, the invertebrate landings showed a steady increase in all three categories.

This data is complemented by Table 7-3, which contains the top commercial landings (by weight) in Martin and St. Lucie Counties during 2005. The listed species each account for at least 1.5 percent of the total county catch by weight for Martin and St. Lucie Counties; 2,107,285 and 1,640,536 pounds, respectively. Together, these counties account for 86.4 and 82.4 percent of the total catch. Most of the species on this list reside in estuarine habitat for at least part of their life cycle.

**TABLE 7-2**
**COMMERCIAL LANDINGS**
**MARTIN AND ST. LUCIE COUNTIES**
**2001-2005**

| MARTIN COUNTY | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Finfish | Pounds | 1,095,994 | 1,058,507 | 2,086,882 | 2,750,949 | 2,107,285 |
| | Trips | 3,262 | 3,536 | 5,659 | 6,394 | 5,470 |
| | Value | $1,545,352 | $1,492,495 | $2,942,504 | $3,878,838 | $2,971,272 |
| Invertebrates | Pounds | 20,728 | 18,052 | 25,394 | 28,956 | 41,806 |
| | Trips | 224 | 201 | 220 | 283 | 848 |
| | Value | $56,380 | $49,101 | $69,072 | $78,760 | $113,712 |
| Bait Shrimp | Pounds | 0 | 0 | 0 | 0 | 0 |
| | Trips | 0 | 0 | 0 | 0 | 0 |
| | Value | 0 | 0 | 0 | 0 | 0 |

| St. LUCIE COUNTY | | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Finfish | Pounds | 3,753,475 | 3,163,073 | 3,212,649 | 2,208,580 | 1,640,536 |
| | Trips | 10,321 | 9,251 | 7,495 | 5,870 | 4,203 |
| | Value | $5,292,400 | $4,459,933 | $4,529,835 | $3,114,098 | $2,313,156 |
| Invertebrates | Pounds | 78,759 | 82,179 | 48,904 | 59,226 | 83,081 |
| | Trips | 567 | 716 | 571 | 518 | 505 |
| | Value | $214,224 | $223,527 | $133,019 | $161,095 | $225,980 |
| Bait Shrimp | Pounds | 1,129 | 166 | 110 | 0 | 0 |
| | Trips | 10 | 1 | 3 | 0 | 0 |
| | Value | $4,211 | $619 | $410 | 0 | 0 |

Source: Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 2006

## TABLE 7-3
## RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT
## MARTIN COUNTY
## 2005

| SPECIES | POUNDS | PERCENT OF TOTAL CATCH |
|---|---|---|
| Spanish Mackerel | 1,276,678 | 60.6% |
| King Mackerel | 334,880 | 15.9% |
| Mojarra | 66,497 | 3.2% |
| Shark | 56,484 | 2.7% |
| Sheepshead | 53,200 | 2.5% |
| Popano | 31,583 | 1.5% |

## ST. LUCIE COUNTY
## 2005

| SPECIES | POUNDS | PERCENT OF TOTAL CATCH |
|---|---|---|
| Spanish Mackerel | 478,326 | 29.2% |
| Shark | 227,771 | 13.9% |
| Swordfish | 170,755 | 10.4% |
| King Mackerel | 138,564 | 8.5% |
| Black Mullet | 100,292 | 6.1% |
| Crevalle Jack | 67,578 | 4.1% |
| Silver Mullet | 45,297 | 2.8% |
| Yellowfin Tuna | 44,367 | 2.7% |
| Mojarra | 38,637 | 2.4% |
| Dolphin | 38,417 | 2.3% |

Source: FF&WCC, F&WRI, Florida Marine Fisheries Information System, 2006

The St. Lucie Estuary also supports guided sportfishing and recreational fishing. According to interviews with local professional sportfishing guides, there are approximately 12 guides who operate in this estuary on a full-time basis. Charters typically fish for tarpon, spotted seatrout, snook, and red drum. Assuming that the guides charge an average of $300 per day, guided sportfishing in the estuary would have an approximate annual value in excess of $800,000. The guides indicate that while the majority of their charters consist of tourists, there are also a significant number of charters by Florida residents. Cited percentage ratios of resident/tourist charters were 40/60 for much of the year and 20/80 during the tourist season (i.e., winter and early spring).

Fishing in the St. Lucie Estuary is also popular with local anglers. Bell et al. (1982) have estimated that the overall economic value of recreational fisheries to a region can be as much as six times that from commercial fisheries. Unfortunately, no current participation rates for recreational fishing in the estuary could be identified during this investigation. However, a general impression of recreational fishing in the St. Lucie Estuary can be constructed using the following studies of recreational fishing in areas that include the estuary.

1. In a 1979 creel census of recreational anglers in the St. Lucie Estuary, Van Os et al. (1980) estimated that 338,797 fish were caught (446,820 pounds). The most abundant fish were sea catfish, but bluefish dominated the catch by weight.
2. The National Survey of Recreational Fishing conducted by the National Oceanic and Atmospheric Administration (NOAA) has collected recreational fishing data for the east and west coasts of Florida. The 1996 recreational landings for the east coast of Florida are presented in Table 7-4 for those species that account for at least one percent of the total catch. Since the survey is for creeled fish, catch-and-release statistics are not available. For some gamefish, such as tarpon, catch-and-release accounts for the entire recreational fishery.
3. Bell et al. (1982) estimate that 61.5 percent of recreational fishing trips are within brackish coastal waters or within three miles of shore, where fisheries stocks are largely dependent on estuaries
4. Nelson et al. (1991) describe bluefish, gray snapper, spotted seatrout, spot, black drum, red drum, and gulf flounder as among the species that are abundant in the adjacent Indian River Lagoon, and by inference, in the St. Lucie Estuary.
5. Milon and Thunberg (1993) conducted a state-wide survey of resident anglers. Milon and Thunberg estimated that, on a state-wide basis, resident anglers make 8.7 fishing trips per year and that 56 percent of trips involved private boats. For Florida Marine Fisheries Commission Region 6, which includes the St. Lucie Estuary, Milon and Thunberg estimated over 65 percent of the total fishing effort was expended in near-shore waters or within the estuary or lagoon complex. Their findings suggest that over 90 percent of the recreational fishing by Florida residents in Region 6 is done by people who reside in the lagoon watershed. In addition, Milon and Thunberg's surveys indicate that sea trout, snook, and red drum are the most popular species with anglers, pursued by 48 percent of the anglers who expressed species preference. The survey results suggest average state-wide daily expenditures by resident anglers of $114.81, with annual expenditures of $576.49 per fisherman. This is consistent with Bell's estimate of $508.97 spent per fisherman on recreational fishing during 1982.

6. Bell (1993) investigated fishing by tourists to Florida. Bell estimated that of those tourists visiting Florida, 16.5 percent had engaged in saltwater fishing in the last year. However, 90 percent of the tourist anglers do not come primarily to fish, and two-thirds of these anglers have no target species. The tourists spend approximately $110 per day while fishing.
7. Bell (1992) investigated the potential changes in tourist visitation resulting from adverse effects on recreational beaches and fisheries. Bell noted a state-wide decline in catch per trip from 5.8 to 4.5 fish/trip from 1979-1990. However, during the same period, he found no relationship between changes in tourism and changes in the catch rates of recreational saltwater fishing in the State.

**TABLE 7-4**
**RECREATIONAL LANDINGS**
**EAST COAST OF FLORIDA**
**1996**

| Species | Landings | Percent |
|---|---|---|
| Saltwater catfishes | 1,016,102 | 4% |
| Spot | 878,155 | 3% |
| Jack, crevalle | 840,862 | 3% |
| Mullets | 752,765 | 3% |
| Other fishes | 696,490 | 3% |
| Snapper, gray | 584,592 | 2% |
| Drum, red | 385,577 | 1% |
| Pinfishes | 358,850 | 1% |
| Kingfishes | 355,793 | 1% |
| Sheepshead | 350,996 | 1% |
| Other grunts | 205,466 | 1% |
| Herrings | 188,775 | 1% |
| Bluefish | 131,526 | 1% |

Source: NOAA. National Survey of Recreational Fishing. 1997.

### 7.3.2 Hydrologic Changes Associated With Alternative Schedules

The SFWMM-simulated hydrologic effects of the alternative regulation schedules on the St. Lucie Estuary are presented in Table 7-5.

**TABLE7-5**
**SIMULATED HYDROLOGIC PERFORMANCE OF ALTERNATIVE REGULATION SCHEDULES**
**ST. LUCIE ESTUARY**

| Performance Measure | 07LORS | 1bS2 | 1bS2_m | 2a | 2a_m | 4 |
|---|---|---|---|---|---|---|
| Number of Mean Monthly Flows < 350 | 128 | 126 | 127 | 135 | 118 | 127 |
| Number of Mean Monthly Flows 350 to 2000 | 230 | 238 | 240 | 223 | 241 | 238 |
| Number of Mean Monthly Flows 2000 to 3000 | 43 | 42 | 36 | 38 | 39 | 37 |
| Number of Mean Monthly Flows > 3000 | 31 | 26 | 29 | 36 | 34 | 30 |

### 7.3.3 Potential Ecological and Economic Effects of Hydrologic Changes

There has been long-standing concern about the effects of regulatory releases on the St. Lucie Estuary. More than 20 years ago, conferences were sponsored by the Florida Oceanographic Society to discuss the ecological impacts of the regulatory releases. Over the years, the level of local awareness of the issues surrounding the ecological effects of the releases has varied in accordance with the release levels.

In 1998, a number of local interests expressed concern regarding the effects of the regulatory releases. Following the extremely wet spring induced by a strong El Nino event, high lake levels required Zone A releases into the St. Lucie Estuary under the Run25 schedule, with release volumes as high as 7,500 cubic feet per second (cfs). The brackish estuary was quickly transformed into a freshwater estuary, and the accumulated sediment on the canal bottom was quickly transported and deposited on the estuary benthos. The concerns of local residents was heightened when deformed mullet and gamefish with lesions were observed in the estuary. Water samples revealed the presence of *Cryptoperidiniopsis*, a marine algae, in the estuary. *Cryptoperidiniopsis* is being investigated by Florida Department of Environmental Protection (FDEP) as the potential cause of the lesions on fish in the estuary. However, at this time *Cryptoperidiniopsis* has not been linked to the lesions in the St. Lucie Estuary or to human health effects anywhere.

Based on available literature, some aspects of the relationship between regulatory releases and ecological effects on fishing are relatively clear. In general, the St. Lucie Estuary ecosystem is stressed by magnified oscillations in freshwater inputs to the estuary and other ecosystem perturbations. The stressors include Lake Okeechobee releases and other influences from the estuary's watershed. The variability in freshwater inputs to the estuary creates an unstable salinity environment (Chamberlain and Hayward, 1996). The turbidity and sedimentation impacts on seagrass communities may be the principal long-term concern regarding freshwater inputs to the estuary (Haunert and Startzman, 1985). However, there are also concerns about the effects of low-flow periods, particularly with regard to dissolved oxygen levels. While in some instances the effects of releases may be difficult to distinguish from watershed effects, it appears that regulatory releases do affect commercial and recreational fisheries in the estuary (Haunert and Startzman, 1980; Van Os et al., 1980).

Unfortunately, there is a great deal of uncertainty regarding the effects of the freshwater releases from Lake Okeechobee on the St. Lucie Estuary. Estuarine ecosystems are complex, and the linkages between causes (e.g., ecosystem perturbations) and effects (e.g., changes in the structure or function of the ecosystem) are often unclear. There are multiple research topics that need to be explored to fully understand these linkages. These topics include distinguishing between: (1) the impacts of regulatory releases and runoff from the watershed, (2) short-term and long-term effects of the releases, (3) the few high level releases and the more numerous smaller events, and (4) low and high flow violations of the desired salinity targets.

Ecological uncertainties compound the economic uncertainties regarding commercial and recreational fishing. An example of the relationship between uncertainties in ecological and economic response to the regulatory releases is provided by the regulatory releases which occurred during the spring of 1998. During 1998 spring releases, gamefish disappeared due to the salinity effects, and the commercial and recreational fishery was severely impacted. However, by June of 1998, gamefish had returned to the estuary and guided sportfishing and recreational fishing had rebounded.

The economic effects would seem to be clearly bounded by the effects on fishing, since adult gamefish relocate during release periods (Van Os et al., 1980). However, the loss of juveniles and loss of habitat due to sedimentation effects on seagrass may not affect fishing and the economics of fishing for years to come. In addition, for those offshore commercial species that reside in estuarine waters during their larval or juvenile stages, the economic effects of changes in the estuarine ecology could be manifested in offshore commercial or recreational landings or in the landings of another county.

The challenge in determining the economic impacts on commercial and recreational fishing in the St. Lucie Estuary is further complicated by the need to differentiate between the with- and without-project future conditions in order to isolate the effects of the alternative regulation schedules. Given these considerations, the determination of an actual dollar estimate of the effects of the alternative plans on commercial and recreational fishing is beyond the limits of this investigation. However, the hydrologic effects of the alternative plans simulated in the SWFMM can be interpreted from the perspective of the fishing industry by combining the profile of commercial and recreational fishing with the current understanding of the ecological effects of regulatory releases on the estuary.

As indicated in Table 7-5, the alternative regulation schedules are all expected to result in improvements over the without-project future condition. However, the alternative regulation schedules are not expected to meet the performance targets. The relative performances of the alternative regulation schedules allow the plans to be compared, but the monetary estimation of the economic effects on the commercial and recreational fishery will require additional research into the ecology and economics of the estuary.

The SFWMD is currently attempting to fill some of the information gaps that exist in the hydrology-ecology-economics chain of cause-and-effect as regards freshwater releases from Lake Okeechobee. In June 1998, the SFWMD sponsored a series of focus groups in Martin and St. Lucie counties that are intended to assemble local businesses affected by the large regulatory releases to the St. Lucie Estuary in the spring of 1998 and to identify the economic impacts on these businesses and the regional economy.

## 7.4 POTENTIAL EFFECTS ON FISHING IN CALOOSAHATCHEE ESTUARY

While the issues regarding Lake Okeechobee releases to the Caloosahatchee Estuary are similar to the St. Lucie Estuary, there are several important differences as well. Similarities include: (1) the purposes and timing of the regulatory and non-regulatory releases from Lake Okeechobee and (2) the uncertainties in the causal relationship between hydrologic changes in the releases, the consequent ecological effects, and the economic impacts on commercial and recreational fishing. Differences include: (1) the larger size of the Caloosahatchee Estuary relative to the St. Lucie Estuary, (2) the larger releases from the lake down this waterway, and (3) the ecological distinctions between the Caloosahatchee and St. Lucie estuaries.

As part of this investigation, a variety of individuals, organizations, and institutions were contacted to identify pertinent studies and individuals with expertise regarding the impacts of the freshwater releases from Lake Okeechobee on the Caloosahatchee Estuary. Contacts included:

- Harbor Branch Oceanographic Institute,
- Caloosahatchee River Citizens Committee,
- Lee County Professional Guides Association,
- Florida Marine Research Institute,
- Florida Sea Grant,
- Florida Bureau of Seafood and Aquaculture,
- Florida Center for Environmental Studies, Tarpon Bay Research Center,
- City of Sanibel,
- Lee County,
- Gulf of Mexico Program,
- Gulf of Mexico Foundation,
- Charlotte Harbor National Estuary Program,
- Southwest Florida Regional Planning Council, and
- SFWMD.

In 1995, Charlotte Harbor, which adjoins the Caloosahatchee Estuary, was included in the NEP. The Charlotte Harbor NEP effort included two studies with direct relevance for this investigation. The first is a review of the physical setting in the Caloosahatchee Estuary. The second is an estimate of the economic value of resources in the Charlotte Harbor study area, which includes the Caloosahatchee River.

Goodwin (1996) modeled the currents in the area of San Carlos Bay and concluded that much of the regulatory discharges from the Caloosahatchee River pass southward under the Sanibel Causeway and enter the Gulf of Mexico. However, under certain conditions, some of this freshwater can be transported into Pine Island Sound and Matlacha Pass. The extent of the effects of regulatory releases from Lake Okeechobee are variable, depending on the release rate and the wind and tidal conditions in the estuary. Based on discussions with some of the previously listed organizations, the effects of large freshwater releases, such as those experienced in the spring of 1998, extend into San Carlos Bay, Matlacha Pass, Pine Island Sound, and Estero Bay. According to local residents, the tannin-colored waters from Lake Okeechobee are quite apparent as they darken the waters of San Carlos Bay.

It appears that the sedimentation effects of the releases on the Caloosahatchee Estuary are less problematic than the nutrient effects of the releases, relative to the St. Lucie Estuary. Red tides (i.e., marine algae blooms) were consistently described during interviews as a more significant ecological and economic threat than freshwater releases from Lake Okeechobee. Red tides kill fish, ruin fishing, and close beaches with the stench of dead fish and the effects of algae on bathers' respiratory systems (e.g., throat and sinus irritation). The two issues may be interconnected, since algae blooms have been linked to nutrient inputs to coastal waters. However, there are significant sources of nutrients in these coastal waters other than water released from Lake Okeechobee. Phosphate mining, agriculture, and wastewater discharges contribute to the nutrient levels in the coastal waters of Lee County.

### 7.4.1 Profile of Commercial and Recreational Fisheries

As in the case of the St. Lucie Estuary, a profile of commercial and recreational fishing in the Caloosahatchee Estuary can be constructed using field information and data in national and state fishing databases. Again, much of the available information about commercial and recreational fishing in the estuary is contained in studies and data sets for larger geographic areas.

There is some commercial fishing in the Caloosahatchee Estuary. The use of cast nets in the estuary is reported to be common. In addition, there is reported to be substantial crabbing activity in the estuary. In Lee County, there are 638 saltwater products licenses and 267 permits for blue crab fishing.

The Caloosahatchee Estuary has important ecological connections with offshore commercial fish stocks. As described in Nelson (1992), many commercial finfish and invertebrate species use estuaries for critical stages of their development. Table 7-6 presents commercial landings, trips, and value data collected by the FDEP for the Pine Island Sound/San Carlos Bay area. As indicated in this table, in 1997 the value of the commercial landings from this area were approximately $1.7 million. The finfish and bait shrimp fisheries account for most of the landings and value. Although the shrimp landings in Table 7-6 are small, there is a significant offshore pink shrimp fishery that is based on Sanibel Island. This fishery is reflected in 1997 pink shrimp landings data for Lee County, which totaled 4,033,537 pounds. The Caloosahatchee Estuary and the area affected by freshwater releases from Lake Okeechobee comprise part of the nursery habitat for this fishery. The finfish and bait shrimp poundage, trips, and value data vary widely from year to year. This is due to changes in the fish population dynamics, fishing conditions, and fishing effort.

**TABLE 7-6**
**COMMERCIAL LANDINGS**
**PINE ISLAND SOUND/SAN CARLOS BAY**
**1993-1997**

| | | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|
| Finfish | Pounds | 1,084,476 | 174,582 | 260,175 | 479,160 | 1,036,342 |
| | Trips | 4,853 | 783 | 1,682 | 2,745 | 3,881 |
| | Value | $629,297 | $134,862 | $274,862 | $492,314 | $867,150 |
| Invertebrates | Pounds | 1,484 | 1,864 | 32,583 | 410,203 | 196,409 |
| | Trips | 11 | 13 | 111 | 1,391 | 1,373 |
| | Value | $1,435 | $1,299 | $31,560 | $219,301 | $247,464 |
| Shrimp | Pounds | 2,017 | 0 | 0 | 0 | 0 |
| | Trips | 9 | 0 | 0 | 0 | 0 |
| | Value | $6,250 | $0 | $0 | $0 | $0 |
| Bait Shrimp | Pounds | 89,165 | 114,982 | 118,009 | 136,356 | 147,564 |
| | Trips | 1,762 | 1,961 | 2,105 | 2,735 | 2,749 |
| | Value | $213,630 | $265,397 | $369,182 | $513,383 | $556,705 |

Source: FDEP, 1997

The data in Table 7-6 are complemented by the information in Table 7-7 and Table 7-8. Table 7-7 contains 1997 landings data from nearby Charlotte Harbor (to the north) and Estero Bay (to the south). As indicated in Table 7-7, the finfish fishery in Charlotte Harbor is substantially larger than that of the Pine Island/San Carlos Bay area.

Table 7-8 contains ranked landings of the top nine commercial species in Lee County, by weight. Each of these nine species account for at least one percent of the total county catch by weight (2,599,308 pounds) and together, they account for 95 percent of the total catch. Most of these species reside in estuarine habitat for at least part of their life stage. The 1997 commercial invertebrate landings for Lee County include: blue crabs (1,409,015 pounds) and stone crabs (151,330 pounds). In addition, the 1997 shrimp landings for Lee County were 4,224,879 pounds.

**TABLE 7-7**
**COMMERCIAL LANDINGS**
**CHARLOTTE HARBOR; ESTERO BAY**
**1997**

| AREA | CATEGORY | POUNDS | TRIPS | VALUE |
|---|---|---|---|---|
| Charlotte Harbor | Finfish | 1,787,612 | 6,103 | $1,293,085 |
| | Invertebrates | 748,850 | 4,446 | $701,355 |
| | Shrimp | 14,609 | 141 | $40,562 |
| | Bait Shrimp | 0 | 0 | $0 |
| Estero Bay | Finfish | 100,947 | 428 | $70,768 |
| | Invertebrates | 2,766 | 25 | $11,236 |
| | Shrimp | 0 | 0 | $0 |
| | Bait Shrimp | 0 | 0 | $0 |

Source: GDEP, 1997.

**TABLE 7-8**
**RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT**
**LEE COUNTY**
**1997**

| SPECIES | POUNDS | PERCENT OF TOTAL CATCH |
|---|---|---|
| Mullet, Black | 1,714,122 | 66% |
| Grouper, Red | 270,762 | 10% |
| Pompano | 134,932 | 5% |
| Mojarra | 80,428 | 3% |
| Jack, Mixed | 71,064 | 3% |
| Grouper, Gag | 39,989 | 2% |
| Jack, Crevalle | 33,991 | 1% |
| Ladyfish | 30,758 | 1% |
| Grouper, Black | 22,737 | 1% |

Source: Florida Marine Fisheries Information System

The Caloosahatchee Estuary also supports guided sportfishing and recreational fisheries. Nelson (1992) described the following recreational species as “highly abundant”, “abundant”, or “common” in the Caloosahatchee Estuary: tarpon, sea catfish, snook, crevalle jack, silver perch, pinfish, spotted seatrout, red drum, black drum, and stripped mullet.

According to interviews with the Lee County Professional Guides Association, there are approximately 60 guides who operate in Lee County, mostly on a full-time basis. Many of the guides fish in the Caloosahatchee River at least some of the time. An even larger number of guides fish in the area that is potentially subject to the effects of Lake Okeechobee releases. It appears that guides will frequently take charters into the Caloosahatchee River to fish for tarpon or to escape windy conditions on the coast. Guides in the area typically pursue tarpon, spotted seatrout, snook, and red drum. Assuming that the guides charge an average of $350 per day, guided sportfishing in the area would have an approximate annual value of $4.8 million. The guides indicate that while the majority of their charters consist of tourists, there are also significant numbers of charters by Florida residents. The ratio of resident/tourist charters of 40/60 was considered representative for much of the year, changing to 20/80 during the tourist season.

Recreational fishing in the Caloosahatchee Estuary is also popular with local anglers. Bell et al. (1982) estimated that the overall economic value of recreational fisheries to a region can be as much as six times that of commercial fisheries. Unfortunately, no current participation rates for recreational fishing in the estuary were identified as part of this investigation. However, a representative picture of recreational fishing in the Caloosahatchee Estuary can be constructed using studies of recreational fishing that include the estuary.

1. The 1996 National Survey of Recreational Fishing conducted by the NOAA for the west coast of Florida are presented in Table 7-9 for those species which account for at least one percent of the catch. Many of those species spend much of their lives in estuarine waters.
2. Bell et al. (1982) estimated that 61.5 percent of recreational fishing trips are within brackish coastal waters or within three miles of shore, where fish stocks are largely dependent on estuaries
3. The state-wide survey of resident anglers by Milon and Thunberg (1993) estimated that for the Florida Marine Fisheries Commission Region 3, which includes the Caloosahatchee Estuary, over 65 percent of the total fishing effort was expended in near-shore waters or within the estuary or lagoon complex. Milon and Thunber’s findings suggest that 88 percent of the recreational fishing by Florida residents in the lagoon is done by people who reside in the region. In addition, their surveys indicate that sea trout, snook, and red drum are the most popular species with anglers, pursued by 48 percent of the anglers who expressed species preference.
4. Bell’s (1993) study of fishing by Florida tourists estimated that 16.5 percent of tourists visiting Florida engaged in saltwater fishing in the last year. However, 90 percent of the tourist anglers do not come primarily to fish, and two-thirds of these anglers have no target species

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**TABLE 7-9**
**RECREATIONAL LANDINGS**
**WEST COAST OF FLORIDA**
**1996**

| SPECIES | LANDINGS | PERCENT |
|---|---|---|
| Seatrout, spotted | 2,762,297 | 11% |
| Pinfishes | 2,486,234 | 10% |
| Sheepshead | 896,605 | 3% |
| Saltwater catfishes | 866,782 | 3% |
| Snapper, gray | 818,934 | 3% |
| Drum, red | 732,176 | 3% |
| Jack, crevalle | 663,931 | 3% |
| Mullets | 278,833 | 1% |
| Groupers | 263,856 | 1% |
| Perch, silver | 236,575 | 1% |
| Grunt, white | 221,545 | 1% |
| Pigfish | 194,270 | 1% |
| Seatrout, sand | 183,686 | 1% |

Source: NOAA. National Survey of Recreational Marine Fishing. 1996.

Lee County is also home to an emerging aquaculture industry. Since the State of Florida instituted the gill net ban in 1994, it has encouraged aquaculture to mitigate the economic effects on watermen and coastal communities and to meet the growing demand for seafood. In Lee County, there are over ten aquaculture farms, which primarily raise hard clams. The Harbor Branch Oceanographic Institute has received a State grant to provide technical support for clam aquaculture. Some of these operations raise seed clams for sale to other aquaculture farmers; others raise mature clams for commercial sale. The seed clam operations typically use a closed (recycling) water system. The clam farms which are raising mature clams in Lee County are located in Pine Island Sound near the midpoint of Pine Island. It is anticipated that the releases from Lake Okeechobee will not have a significant effect on aquaculture operations in Lee County for two reasons: (1) the seed clams, which are potentially vulnerable to sudden and drastic salinity changes, are not exposed to the freshwater releases from the Caloosahatchee River and (2) the clam farms that raise clams to maturity are sufficiently removed from the more extreme effects of the freshwater releases.

### 7.4.2 Hydrologic Changes Associated With Alternative Regulation Schedules

**TABLE 7-10**
**SIMULATED HYDROLOGIC PERFORMANCE OF ALTERNATIVE PLANS**
**CALOOSAHATCHEE ESTUARY**

| Performance Measure | 07LORS | 1bS2 | 1bs2_m | 2a | 2a_m | 4 |
|---|---|---|---|---|---|---|
| Number of Mean Monthly Flows < 450 | 195 | 114 | 117 | 134 | 128 | 128 |
| Number of Mean Monthly Flows 450 to 2800 | 157 | 243 | 242 | 218 | 241 | 233 |
| Number of Mean Monthly Flows 2800 to 4500 | 46 | 39 | 36 | 40 | 33 | 34 |
| Number of Mean Monthly Flows > 4500 | 34 | 36 | 37 | 41 | 37 | 37 |

### 7.4.3 Potential Ecological and Economic Effects of Hydrologic Changes

Based on available literature, some aspects of the relationship between the regulatory releases and effects on fishing are relatively clear. In general, the Caloosahatchee Estuary ecosystem is stressed by the magnified oscillations in freshwater inputs to the estuary and other ecosystem perturbations. The stressors include the Lake Okeechobee releases and other influences from the estuary's contributing watershed. As in the St. Lucie Estuary, the variability in freshwater inputs to the Caloosahatchee Estuary creates an unstable salinity environment. The work of Doering and Chamberlain (1997) suggests that turbidity and dissolved oxygen levels are comparable to other Florida estuaries, but nitrogen concentrations are relatively high. Doering and Chamberlin also note that, in general, water quality deteriorates with distance upstream from the mouth of the estuary. While in some instances the effects of the releases may be difficult to distinguish from effects of the Caloosahatchee River's relatively large watershed, it appears that the regulatory releases affect the commercial and recreational fisheries in the estuary.

Unfortunately, as in the case of the St. Lucie Estuary, there is a great deal of uncertainty regarding the effects of the freshwater releases from Lake Okeechobee on the Caloosahatchee Estuary. Estuarine ecosystems are complex, and the linkages between causes (e.g., ecosystem perturbations) and effects (e.g., changes in the structure or function of the ecosystem) are often unclear. There are multiple research topics that need to be explored to fully understand these linkages. These topics include distinguishing between the effects of: (1) the impacts of lake releases and freshwater inflow from the watershed, (2) short-term and long-term effects of the releases, (3) the few high level releases and the more numerous smaller events, and (4) low and high flow violations of the desired salinity envelope.

The ecological uncertainties compound the economic uncertainties regarding commercial and recreational fishing. As in the St. Lucie Estuary, the return of gamefish following a period of large releases to the estuary may not fully reflect the impacts on the fisheries. The economic effects would seem to be clearly bounded by the effects on fishing, since adult gamefish relocate during release periods (Van Os et al., 1980). However, the loss of juveniles and loss of habitat due to impacts on seagrass communities may not affect fishing and the economics of fishing for years to come.

The challenge in estimating the economic effects on commercial and recreational fishing in the Caloosahatchee Estuary is further complicated by the need to differentiate between the with- and without-project future conditions in order to isolate the effects of the alternative regulation schedules. Given these considerations, the determination of a dollar value of the effects of the alternative plans is beyond the scope of this investigation. However, the simulated hydrologic effects of the alternative plans can be interpreted from the perspective of the economics of commercial fishing by combining the profile of commercial and recreational fishing with current understanding of the ecological effects of regulatory releases on the estuary.

As indicated in Table 7-10, the alternative regulation schedules are expected to result in improvements over the without-project future condition with respect to low and high water inputs to the Caloosahatchee Estuary. However, the alternative regulation schedules are not expected to meet the performance targets. The relative performances of the alternative regulation schedules allow the plans to be ranked, but the monetary estimation of the economic effects on the commercial and recreational fishery will require additional research into the ecology and economics of the estuary.

## 7.6 SUMMARY OF POTENTIAL ECONOMIC EFFECTS ON FISHING

The potential effects of the alternative LORS are summarized in Table 7-11. This table presents estimates of current annual revenues for each of the fisheries under consideration. As described in the above discussions, these estimates were generated using a variety of approaches and data sources. Consequently, the estimates should be considered approximate, and comparisons of the revenues of one fishery with another should be made with caution. Table 7-11 also contains information on the anticipated hydrologic performance of the alternative regulation schedules. In general, the alternative plans are expected to comprise improvements over the without-project future conditions. The economic interpretation of this hydrologic information suggests that the alternative plans could result in improvements in the economics of commercial and recreational fishing relative to the existing and without-project future conditions. The quantification of the expected economic impacts is not possible at this time given knowledge and data gaps in the sequence of hydrologic, ecological, and economic effects that determine economic impacts of the alternative regulation schedules.

**TABLE 7-11**
**SUMMARY OF ECONOMIC EFFECTS OF ALTERNATIVE PLANS ON ESTUARINE FISHERIES**

| Area | Approximate Annual Revenues of Fishery ($ million) | | | Hydrologic Performance Of Alternative Schedules | | Economic Interpretation of Hydrologic Performance |
|---|---|---|---|---|---|---|
| | Commercial | Guided | Recreational | Performance Relative to Without-Project Conditions | Performance Relative to Targets | |
| St. Lucie Estuary | $1.7 | $0.8 | n.a. | Alternatives meet or exceed Run25 performance | Alternatives do not meet targets | Positive economic impacts expected with alternative regulation schedules |
| Caloosahatchee Estuary | $1.7 | $4.8 | n.a. | Alternatives meet or exceed Run25 performance | Alternatives do not meet targets | Positive economic impacts expected with alternative regulation schedules |

# 8. REGIONAL ECONOMIC IMPACTS

## OVERVIEW

This chapter examines the potential effects of the alternative regulation schedules on the RED account. The RED account registers indirect and secondary effects to the region that are expected to result from the direct economic effects of the alternative plans. Direct economic effects represent the impacts of economic stimuli in terms of changes in regional industrial output, earnings, or employment. Indirect economic impacts represent the resultant economic changes in the industries that support and rely upon the industries directly affected by the stimuli. In addition, induced economic impacts are those impacts experienced by all local industries as direct and indirect effects alter household income and ultimately change local household spending patterns.

## 8.1 METHODOLOGY

A regional input-output model, *IMPLAN*, was used to estimate the RED effects of the alternative LORS. Regional input-output (I-O) analysis provides the classic tool for tracing economic ripples through the economy. Based on the region's industrial structure, I-O analysis tracks the expected inter-industry flow of goods and services. For the RED analysis, the regional economy was defined as encompassing 13 Florida counties (Broward, Charlotte, Collier, Dade, Glades, Hendry, Highlands, Lee, Martin, Monroe, Okeechobee, Palm Beach, and St. Lucie) using *IMPLAN*. Using county-level economic data, which was procured from the software vendor, the model was used to estimate the economic effects of the alternative regulation schedules on wages, employment, and industrial output. Specifically, *IMPLAN* was employed in a four-part methodology to: (1) describe the study area economy, (2) create economic scenarios, (3) introduce economic changes, and (4) estimate resulting direct, indirect, and induced economic effects.

Economic scenarios were created in *IMPLAN* to characterize the future conditions in each industry under each regulation alternative. Not all of the potential direct effects can be evaluated in the RED analysis. For example, it was not possible to evaluate the M&I water supply effects of the alternative plans in the RED account. The M&I water supply effects associated with the alternative regulation schedules were developed using willingness-to-pay estimates for water supplies that would be unavailable during water shortages. Industrial water users may experience monetary income losses associated with water use cutbacks during shortages, but these effects cannot be distinguished from the combined willingness-to-pay values derived from a survey of industrial, commercial, and residential users. In addition, commercial and residential water users primarily experience non-monetary effects from water shortages, representing their loss of satisfaction, rather than a reduction in household income.

Similar willingness-to-pay issues precluded some agricultural water supply effects from inclusion in the RED account. Specifically, urban landscape and golf turf effects were calculated using WTP estimates. Since these estimates also represent reductions in satisfaction, not reductions in income, they were excluded from the RED analysis. In addition to M&I water supply and several agricultural water supply categories, three other NED categories (e.g., commercial navigation, recreation, and commercial fishing) were not evaluated in the RED analysis. There are two principal reasons for this exclusion. First, the alternative regulation schedules are expected to have minor economic consequences associated with commercial navigation, recreation, and commercial fishing. Second, the procedures used to estimate the NED effects on these economic categories generated illustrative scenarios, not quantitative estimates of NED effects. Consequently, interpretations of their results should be limited to comparisons of the alternative plans.

Recognizing these exclusions, the RED analysis focused on the indirect and induced effects of the agricultural water supply impacts of the alternative regulation schedules. The total agricultural water supply effects generated using the SFWMM's EPP for each service area were developed in Chapter 2 of this report. For the RED analysis, these values have been distributed into the nine agricultural sectors used by the SFWMM and its EPP: urban landscape, sod, nursery, golf turf, tomatoes, avocados, citrus, rice, and sugarcane (see Table 8-1). The agricultural effects (i.e., the value of unmet demand) presented in Table 8-1 represent changes in farm income (or industry output) associated with each alternative regulation schedule and the without-project condition (LORS2007).

**TABLE 8-1**
**SIMULATED 2010 AVERAGE ANNUAL VALUE OF UNMET AGRICULTURAL WATER DEMAND BY AGRICULTURAL SECTOR IN THE LEC AND EAA**

| EPP LAND USE CATEGORY | | ALTERNATIVE REGULATION SCHEDULES | | | | |
|---|---|---|---|---|---|---|
| | LORS2007 | 1bs2 | 1bs2_m | 2a | 2a_m | 4 |
| Urban landscape | $0 | $0 | $0 | $0 | $0 | $0 |
| Other – Sod | $0 | $0 | $0 | $0 | $0 | $0 |
| Nursery | $0 | $0 | $0 | $0 | $0 | $0 |
| Golf turf | $0 | $0 | $0 | $0 | $0 | $0 |
| Tomatoes (vegetables) | $0 | $0 | $0 | $0 | $0 | $0 |
| Citrus | $0 | $0 | $0 | $0 | $0 | $0 |
| Avocado | $0 | $0 | $0 | $0 | $0 | $0 |
| Rice | $0 | $0 | $0 | $0 | $0 | $0 |
| Sugarcane | $39,864 | $76,922 | $84,637 | $192,657 | $352,099 | $141,021 |
| **Total** | **$39,864** | **$76,922** | **$84,637** | **$192,657** | **$352,099** | **$141,021** |

## 8.2 RESULTS

In Table 8-2, the direct economic effects and aggregated indirect and induced economic effects are presented for the alternative schedules. These tables contain the direct effects of the alternative plans to seven agricultural sectors, commercial navigation, recreation, and commercial fishing. The combined induced and indirect effects, summarized in these tables represent the RED effects for all other industries affected by changes in the agricultural, commercial navigation, recreation and commercial fishing industries. Again, RED effects resulting from reductions in M&I water use and the agricultural uses of urban landscape and golf turf have not been estimated. Economic impacts to total industry output and employee compensation are expected to persist through each project year, while employment effects represent the total job loss or gain over the entire project period. Wages include salaries, non-wage compensation, and benefits. Employment is measured as the number of jobs, not necessarily full-time equivalents.

Due to the lack of impacts to non-sugar agriculture entities, the RED analyses of the five alternative regulation schedules focus on their estimated effects on the sugar industry, specifically yields of sugarcane agriculture. While the *IMPLAN* I-O software does not explicitly describe the linkages between direct and indirect or induced effects, presumably the consequent impacts of the reduced sugarcane production on sugar mills and other sugar-related activities are registered in the following regional economic sectors: sugar crops, food and manufacturing, and transportation and communication.

Tables 8-1 and 8-2 present the *IMPLAN* output for direct, indirect, and induced impacts of the five alternatives, while Table 8-3 is an aggregate of both, and their percentage of overall regional impacts.

**TABLE 8-2**
**DIRECT, INDIRECT AND INDUCED IMPACTS ON EMPLOYEE COMPENSATION AS A RESULT OF ALTERNATIVE MODEL RUNS (2006 Dollars)**

| ALTERNATIVE | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| LORS2007 | $-3,495 | $-4,287 | $-12,325 | $-20,106 |
| 1BS2 | $-6,744 | $-8,216 | $-23,798 | $-38,758 |
| 1BS2_M | $-7,420 | $-9,041 | $-26,184 | $-42,645 |
| 2A | $-16,889 | $-20,719 | $-59,563 | $-97,171 |
| 2A_M | $-30,869 | $-37,609 | $-108,930 | $-177,409 |
| 4 | $-12,363 | $-15,166 | $-43,599 | $-71,128 |

**TABLE 8-2**
**DIRECT, INDIRECT AND INDUCED IMPACTS ON REGIONAL OUTPUT AS A RESULT OF ALTERNATIVE MODEL RUNS (2006 Dollars)**

| ALTERNATIVE | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| LORS2007 | $-38,447 | $-12,876 | $-32,863 | $-84,186 |
| 1BS2 | $-74,188 | $-24,707 | $-63,439 | $-162,334 |
| 1BS2_M | $-81,629 | $-27,185 | $-69,802 | $-178,616 |
| 2A | $-185,810 | $-62,226 | $-158,824 | $-406,860 |
| 2A_M | $-339,586 | $-113,039 | $-290,383 | $-743,062 |
| 4 | $-136,010 | $-45,548 | $-116,257 | $-297,815 |

## TABLE 8-3
## OVERALL REGIONAL NEGATIVE ECONOMIC IMPACTS OF THE ALTERNATIVES (DIRECT AND INDIRECT IMPACTS)*

| Alternative | Direct and Indirect Impacts | | |
|---|---|---|---|
| | Output (2006 $) | Employee Compensation (2006 $) | Employment (FTE) |
| LORS2007 | - 84,186 | - 20,106 | - 2 |
| % of Regional Total | -.000000047% | -.00000012% | -.00000041% |
| 1bs2 | 162,334 | 38,758 | -3.8 |
| % of Regional Total | -.000000091% | -.00000023% | -.0000079% |
| 1bs2_m | -178,616 | -42,654 | -4.2 |
| % of Regional Total | -.000000099% | -.00000026% | -.0000087% |
| 2a | -406,860 | -97,171 | -7.3 |
| % of Regional Total | -.00000023% | -.00000058% | -.0000014% |
| 2a_m | -743,062 | -177,409 | -17.3 |
| % of Regional Total | -.00000041% | -.0000011% | -.0000036% |
| 4 | -297,816 | -71,128 | -6.9 |
| % of Regional Total | -.00000041% | -.0000011% | -.0000036% |

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